Available online at www.elixirpublishers.com (Elixir International Journal)

Civil Engineering

Elixir Civil Engg. 100 (2016) 43763-43767

ISSN: 2229-712X

Properties of light weight Concrete Containing polypropylene fiber Using Waste Thermostone as Aggregate

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ARTICLE INFO

Article history:

Received: 17 October 2016;

Received in revised form:

17 November 2016;

Accepted: 26 November 2016;

Keywords

Polypropylene Fibers,
Light Weight Concrete,
Thermostone,
Compressive strength,
Water absorption.

ABSTRACT

The influence of polypropylene fibers has been studied to improve the mechanical properties of lightweight concrete with Waste of Thermostone blocks used to produce lightweight coarse aggregate. The volume fractions of the polypropylene fibers (P.P.F.) used are: 0.0% for reference light weight concrete, and 0.25%, 0.5%, 0.75%, 0.1%, and 1.25% total volume of concrete for other mixes. The density, compressive strength and splitting tensile strength, Flexural strength, and water absorption were measured. The results shows, generally, the mechanical properties of lightweight concrete increased with rising the percentages of polypropylene fibers. With P.P. fibers proportioning 1.0% at 28 days caused 13.93% increase in compressive strength and 43.65% increase in the splitting tensile strength and 41.69%increase in the flexural strength, therefore, it is used as the optimum proportion of the polypropylene fibers. The flowability of lightweight concrete reduced by addition polypropylene fibers, therefore Super plasticizer was used to improve the workability of fresh light weight concrete. The equilibrium densities of structural lightweight concrete method was used to determine the density of Lightweight P.P.F. and was 1789Kg/m3. Also, the results showed that there are increases in the water absorption for mixes with P.P.F.as compared with reference mix.

1.Introduction

In concrete construction, self-weight usually represents a very large proportion of the total load on the structure, and there are considerable advantages in reducing the density of concrete. The chief of these are a reduction in dead load and therefore in total load on the various members and corresponding reduction in the size of foundation [1] .And lower coefficient of thermal conductivity [2, 3].Thermostone is a lightweight cement-based material, containing many gas bubbles evenly distributed in the volume, produced by blending and maturing of a mixture of cement, sand, lime, water, agent generating cells. The efficacy of fiber reinforcement in the concrete to improve the mechanical properties of concrete. Polypropylene (P.P.) fibers were manufactured chemical fibers, having the fourth largest volume in production after polyesters, polyamides and acrylics [4].

2. Literature Review

Many examinations have been completed on the utilization of light weight Concrete Containing polypropylene fiber.

Faiz A. Mirza., et al.in (2016)[5] used self-compacting polypropylene fibers lightweight concrete (SCFLWC) made from natural lightweight aggregate Mixes with different fiber volume fractions (0.0, 0.2, 0.4 and 0.6%) at different levels of fly ash (0.0, 10, 20 and 30%) as a replacement by weight of cement were prepared and tested. Test results indicated that Polypropylene fiber have a little effect on the compressive strength and elastic modulus of SCFLWC.But these fibers at their maximum percentage volume fraction increased the mechanical properties especially at 90 days.Roohollah Bagherzadeh et al. in (2012) [6] Studied the influence of polypropylene P.P. fibers on the Lightweight Cement Composites (LWC).Fibers used in two different lengths (6mm and 12mm) and fiber proportions (0.15% and 0.35%) by cement weight. Results shown that the fiber length of 12 mm showed better performance compared to 6 mm in compressive strength, also the specimens with longer length of PP fiber showed better flexural strength in compare with specimens with smaller fibers. Mohamed R. A. S. (2006)[7]. Investigated the effect of the addition of polypropylene fibers on the mechanical properties of normal strength concrete. The polypropylene fibers were added at concentration of 0.25, 0.5, 1.0 and 1.5% by volume. Concluded that, ductility of concrete significantly increased and maximum compressive strength slightly increased with increasing the content of polypropylene fibers. Mehul J. Patel's. M. KULKARNI (2012).[8] investigated the strength properties of concrete containing polypropylene fiber and class C fly ash. Polypropylene fiber of volume fractions of 0.15, 0.20, 0.25, and 0.30 was used for all fly ash concrete mixes. Results shown that Compressive strength and Splitting Tensile strength of concrete increases gradually by addition of Polypropylene fiber from 0.15% to 0.30% and Flexural test of concrete gradually increases with the addition of Polypropylene fiber.

3. Materials

3.1 Cement

Ordinary Portland cement was used in this work type Al-Douh. Test results indicated that the cement conformed to ASTM Specf.C150-02a/2002[9] .The chemical and physical analysis of cement are shown in the Table 1 and 2 Ordinary Portland cement was used in this work type Al- Douh.

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3.2. Aggregate

3.2.1. Waste Crushed Thermostone Coarse Aggregate

This type of aggregate was used as coarse aggregate and the large pieces were crushed into smaller sizes manually by means of hammer. Brought from different work places. Crushing products were screened into four size fractions (25 to 19mm, 19 to 9.5mm, 9.5 to 4.75mm and 4.75 to 2.36mm) by using a sieve shaker. Table 3 shown the grading according to ASTM Standard C330-05[10] with Max. Size 19mm.

3.2.2. Fine aggregate

Clean washed sand. With a 4.75 mm maximum size is used as fine aggregate. The grading of fine aggregate are listed in Table (4) and compatible to the requirement of ASTM C33-01[11]

3.3. Water

Ordinary tap water was used for mixing and curing for all concrete mixes of this work.

3.4. Polypropylene Fiber (P.P.F.)

High execution short (10 mm) polypropylene fiber was used in this investigation. Polypropylene fiber complied with requirements of ASTM C1116-02 [12]. It was stored under cover away from heat sources. Table (5) shows the physical and technical properties of polypropylene fiber.Figuer (1) shown the polypropylene fibers.

3.5. High Range Water Reducing admixture (Mega Flow SP4).

Super plasticizer is high range water reducing admixture specifically designed for producing high slump, It meet the requirements of super plasticizer according to ASTM-C494 Type B, D, and G [13].Table (6) shown the typical properties of super plasticizer.

4. Concrete Mixes

The reference mixture is made by Standard Practice for Selecting Proportions for Structural Lightweight Concrete (ACI 211.2-98)[14] and five concrete mixtures were same reference mixture (C1) but contain polypropylene fiber there are (0.25%,0.5%,0.75%,1%,and1.25%)for mixes (C2,C3,C4,C5,C6) by volume of concrete respectively .Table (7) shown the mixes of light weight concrete with waste Thermostone coarse aggregate. Super plasticizer used throughout this investigation to increase the workability of fresh concrete with slump test (200-100) for all mixtures the aggregates in this work was used in saturated surface dry case (S.S.D.) Table (7) shown the mixes of concrete .

5. Mixing of concrete

The dry materials are well mixed for about 1.5 minutes to attain uniform mix. After that the Polypropylene fibers were added slowly by the hand and mixing was working for 2.5 minutes. Finally the required water with Super plasticizer was added to the mix without segregation.

6. Casting and curing of the test specimens.

The molds were coated with oil before use, for easy out sample and then fill the mold with each layer 50 mm of the mixture and with each layer compacting by vibrating table for (20-30) second to ensure out the bubbles and distribution, according to ASTM C192-88 [15]. After that, the top surface of the molds were smoothing. Cover the specimens immediately after finishing to prevent evaporation of water from unhardened concrete .Remove the specimens from the molds 24 hours after casting and marker .Lastly, immersed in water until the age of test.

7. Concrete testing

For each mix, six (100mm) standard cubic steel molds are used for casting specimens used for compressive strength at 7 and 28 days, according to BS1881 part 116-89 [16], the splitting tensile strength were used two molds of 100X200 mm cylindrical concrete specimens was measured in accordance with the ASTM C 496- 86[17] .Two (100X100X400mm) prisms for flexural strength at 28 days correspond with ASTMC78-84 [18] .For water absorption test were used two 100mm cubes according to ASTM C642 [19].

8. Results and Discussion

8.1. Equilibrium Density of Lightweight Concrete

Test Method ASTM C 567-00[20] was used to determine the Equilibrium density of lightweight concrete and was 1789 Kg /m^3 and that satisfied the requirement of ACI211.2-89: state that not exceeding (1842 Kg /m3).

8.2. Results of Compressive Strength Test.

The present of the fibers in the concrete, makes it's more ductile due to propagation of failure cracks are restrained by the bond-ing of fibers in to the concrete and enhances the energy capacity for cracking load. It is observed that in the Table (8) and Figure (2) at 7 and 28 days, all concrete mixes with Polypropylene Fibers (P.P.F.) shown an increase in the compressive strength. The percent of increasing in the compressive strength at 7 days approximately, (4.60%, 8.5%,11.5%, 13.93%, 9.7612.14%) ,while at 28 days , (5.03%,7.53%,12.73%,24.64%,20.63%) the increasing in the compressive strength at 28 days was more than their conformable compressive strength at 7 days due to the condensation of product of hydration process about the Polypropylene Fiber and in the voids of concrete.[21], figure(2) shown that he bond strength increased significantly with increasing polypropylene fibers content up to 1.00 vol. %. Because of increases the (P.P.F.) were stopping the growth of micro cracks in the orientation of load. [7].

When adding 1.25% of Polypropylene Fibers to the mixture of concrete lessen the increasing in the compressive strength in comparison with 1%. But rest higher than reference concrete (C1). This is may be due to conglobate of the fibers that may take place and the fibers-aggregate interaction.

8.3. Results of Splitting Tensile Strength Test

Table (9) shows the results of splitting tensile strength test for light weight concrete mixes and plotted in Fig. (3). , after 28 days of water curing, it was found that the Splitting Tensile Strength of light weight concrete mixes with Polypropylene fibers increases compared to the reference concrete without P.P.F. Also splitting tensile strength test exhibited a clear increases with increasing Polypropylene fibers percentage. Because of improvement in the mechanical bond strength of concrete and the ability to delay the fine-crack formation and fixing their propagation.

8.4. Results of Flexural Strength Test.

The flexural strength of the specimens was measured at the ages of 7, and 28.From the test results presented in the table (10) and Figure (4), it can be noticed that flexural strength of the mixes made with the Polypropylene fibers exhibited increases in flexural strength with increasing in the Polypropylene fibers. This can be attributed the increase may be resulted from the fibers intersecting the crack in the tension and providing an additional energy absorbing mechanism.[22] .Figure (3) It can be observed that Flexural Strength of the fiber light weight concretes is better than the control concrete.

8.5. Water Absorption Test

Evaluation of light weight Hardened Concrete at 28 days of curing .Results of water absorption of concrete specimens are shown in Table (11) and Figure 5. The water absorption of all specimens increases by adding polypropylene fibers. Maximum increase in water absorption for C6 was in order of 9.41% .it might be presumed that expansion in water absorption is because of the voids that may be formed in concrete during the mixing time [6].

Table1. Chemical Analysis of cement

Oxides	percentage	Limit of ASTM Specf.C150-02a/2002
CaO	63.2	-
SiO2	18.9	-
Al2O3	3.8	-
Fe2O3	4.6	-
SO3	1.5	≤ 2.3
MgO	1.7	≤ 6.0
L.O.I	1.9	≤ 3.0
L.S.F	0.9	-
I.R.	0.4	≤ 0.75
C3A	2.32	≤ 5.0

Table 2. Physical properties of cement

Physical properties	Test results	Limit of ASTM Specf.C150-02a/2002
Initial setting time (vicat)	65 min.	45min. (Min.)
Final setting time (vicat)	170 min.	375 min. (Max.)
Compressive strength of mortar (MPa) 3-days	19.0	15 (Min.)
Compressive strength of mortar (MPa)7-days	30.5	21 (Min.)

Table 3. Grading of natural and crushed brick coarse aggregates.

Sieve size (mm)	Percent Passing	Limit required by ASTMStandardC330-05
25	100	100
19	97	90-100
9.5	39	10-50
4.75	9	0-15
75 µm	1	0-10

Table 4. Sieve analysis of fine aggregate.

Sieve size	Passing ratio (%)	Limit of ASTMC33-01
9.5mm	100.00	100
4.75mm	94.56	95-100
2.36mm	72.45	80-100
1.18mm	68.40	50-85
600µm	53.32	25-60
300µm	16.60	5-30
150µm	2.12	0-10

Table 5. Physical properties of light weight coarse aggregate (Thermostone).

Physical properties	Test results	Limit required by ASTMStandardC330-05
Specific gravity	1.14	----
Absorption	53.6%	----
Bulk density(dry loose)	560	880

Table 6. Physical and Technical Properties of Polypropylene Fiber (P.P.F.)

Properties	Specifications
Tensile strength	350 MPa
Fiber length	12 mm
Specific gravity	0.91 g/cm3
Young's modulus	5000 MPa
Fiber thickness	18 µm
Elongation	25%
Colour	White

Table 7. shown the typical properties of super plasticizer

Properties	Specifications
Specific gravity	1.2
Form	Liquid
PH	7-9

Figure 1. (a)Shown the polypropylene fibers (b) shown the Waste Crushed Thermostone Coarse Aggregate .

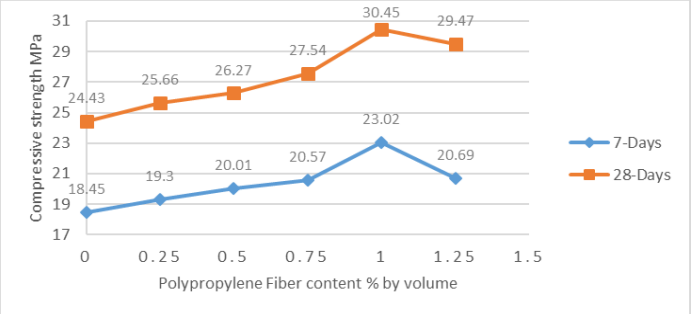

Figure 2. Compressive strength with P.P.F.percent content.

Table 8. Mixes of concrete used throughout This Investigation.

Mix designation	P.P.F.%	Cement Kg/m3	Fine aggregate Kg/m3	Waste Coarse Thermostone Aggregate Kg/m3	Water/cement ratio	S.P.% Of cement
C1	0.00	380	500	700	0.32	0.65
C2	0.25	380	500	700	0.32	0.70
C3	0.50	380	500	700	0.32	0.75
C4	0.75	380	500	700	0.32	0.80
C5	1.00	380	500	700	0.32	0.83
C6	1.25	380	500	700	0.32	0.90

Table 9. Average test result of compressive strength at 7 and 28 days.

Mixes	Compressive strength MPa -7days	Percentage of increase in 7-days	Compressive strength MPa -28days	Percentage of increase in 28-days
C1- 0.00% PPF	18.45	----	24.43	-----
C2- 0.25% PPF	19.30	4.60	25.66	5.03
C3 -0.50% PPF	20.01	8.50	26.27	7.53
C4- 0.75% PPF	20.57	11.50	27.54	12.73
C5 -1.00% PPF	23.02	13.93	30.45	24.64
C6 -1.25% PPF	20.69	12.14	29.47	20.63

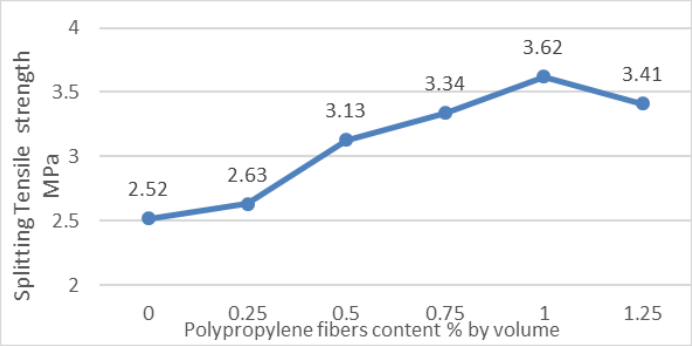

Figure 3.Compressive strength with P.P.F.percent content.

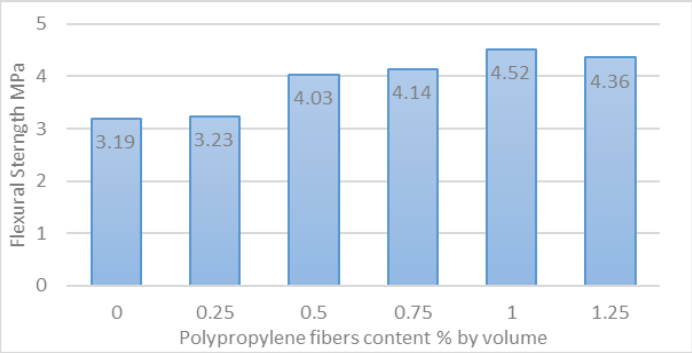

Figure 4. Flexural strength with P.P.F.percent content.

Table 10. Test results of Flexural strength MPa at 28 days.

Mixes	Flexural strength MPa -28days	Percentage of increase in 28-days
C1- 0.00% PPF	3.19	-----
C2- 0.25% PPF	3.23	12.5
C3 -0.50% PPF	4.03	26.33
C4- 0.75% PPF	4.14	29.78
C5 -1.00% PPF	4.52	41.69
C6 -1.25% PPF	4.36	36.67

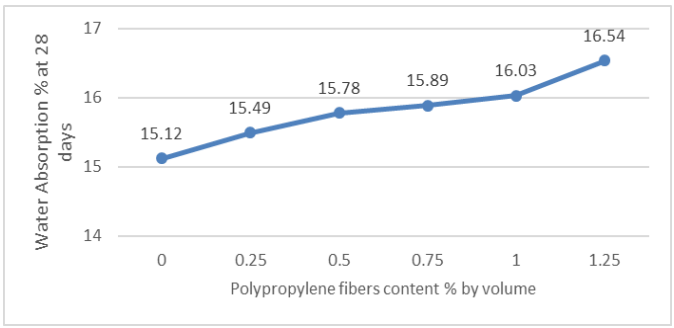

Figure 5. Water Absorption at 28 days with P.P.F.percent content.

9. Conclusions

On the premise of six mixes described in the study, using Polypropylene fibers, with different percentages(0.25%,0.5%,0.75%,1%,and1.25%), and these Mixes are tested in compressive, flexural and splitting tensile strength at age of 7 and 28 days, and water absorption main conclusions can be summarized, as follows:

9.1. Density

Results show that the equilibrium density of light weight concrete with P.P.fibers about (1789) kg/m3.

9.2. Compressive Strength

There was a slight increase in the compressive strength with increasing the fiber volume fraction, the fiber volume is tending to make air voids have a negative effect on the compressive strength. And the percent of increasing varied (4.60%-13.93%) at 7 days and (5.03-24.64) at 28 days in comparison with reference mix.

The optimum proportion of P.P.F. was 1% by volume of concrete with increases the percentage of P.P.F. To 1.25% showed that decreasing in the compressive strength.

9.3. Flexural Strength

Test results indicated that, the Flexural Strength of (1%) P.P. fibers light weight concrete specimens have the higher value of Flexural Strength compared with other mixes was 5.62 MPa at 28 days with increased of 68.42% compared with reference mix. In general, Flexural Strength of light weight concrete increase with adding P.P. fibers.

9.4. Splitting Tensile Strength

The comparison of percentage difference in splitting tensile strength for polypropylene fibers concrete to its control mix. the percentage increase in tensile strength for polypropylene fibers mixes containing fiber by volume fraction of (0.25%, 0.5%, 0.75%,1%,1.25)were (4.36%,24.2%,32.53%,43.65%,35.31) respectively.

9.5. Water Absorption test

On increasing the percentage of polypropylene fibers, the Water Absorption of Light weight concrete was found to increase by 2.39% -9.41%.compared with control mi

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