Civil and Environmental Research
ISSN 2224-5790 (Paper) ISSN 2225-0514 (Online)
Vol.11, No.12, 2019

An Experimental Investigation of Mechanical Properties of The Ultra-High Performance Fiber Reinforced Concrete (UHPFRC)

Dr. Reza Aghayari and Ammar O. AL-Mwanes
Razi University, Iran

Abstract

Ultra-high performance concrete (UHPC) is a novel relatively construction material exhibiting enhanced mechanical and durability properties, which can lead to economical construction through reducing the cross-sections of structural. A study has been made through this investigation to understand the behavior of Ultra-High-Performance Concrete members with steel and polypropylene fibers. The research included the use of a cement, quartz sand, silica fume , steel fibers, polypropylene, superplasticizers and without using any type of aggregates other than the quartz sand Results show that it is possible to produce UHPFRC using materials that are available at the local markets if they are carefully selected and will achieve a minimum compressive strength of (170.32) MPa and The flexural strengths of (23.54) MPa and splitting tensile of(19.1) MPa at the age of 28 days. This can be seen the experimental results showed a significant improvement in the residual mechanical properties of the concretes which contain the mix of fibers compared to concrete mixes without fibers.

Keywords: Polypropylene Fibers; Steel Fibers; Ultra High Performance Concrete
DOI: 10.7176/CER/11-12-01
Publication date: December 31st 2019

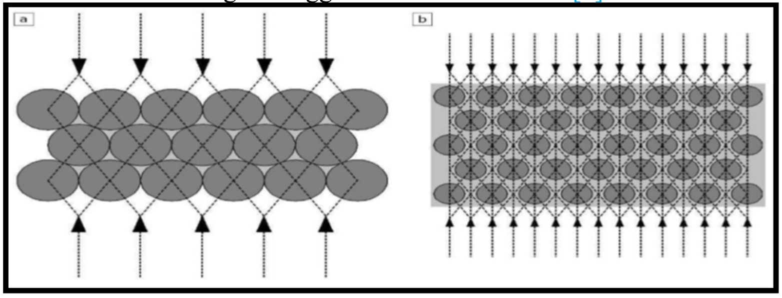
1. INTRODUCTION

Ultra-high Performance Concrete (UHPC) is a very dense structured fine or coarse aggregated concrete with a low water /cement ratio smaller than 0.30, high cement content and mineral admixtures, which are selected to increase the bond between the aggregates and the cement past. The optimization of granular mix for UHPC leads to minimize number of defects such as micro cracks and pore spaces that allow achieving a greater percentage of the potential ultimate load carrying capacity defined by its components and providing enhanced durability properties. Because of the high compressive strength, this type of concrete is named Ultra High Strength Concrete [1]. Ultra-high-performance concrete is a relatively new type of concrete, which is also characterized by its constituent material make-up: typically fine-grained sand, silica fume, small steel fibers or basalt aggregates, and Portland cement, with a low water/cement ratio, high cement content and mineral admixtures that are selected to increase the bond between the aggregates and the cement paste. From the strength point of view, the classification of concrete strength may be made as shown in Table (1) [2,1].

Table (1): classification of concrete strength

Type	From(Mpa)	T0(Mpa)
Normal Strength Concrete (NSC)	--	B41/60
High Strength Concrete (HSC)	B41/60	B70/90
Very High Strength Concrete (VHSC)	B70/90	B120/150
Ultra- High Strength Concrete (UHSC)	B120/150	B200/250
Super High Strength Concrete (SHSC)	B200/250	NO limits

An extensive literature review has been conducted on the material characterization of UHPC and its potential for large-scale field applicability. The successful production of ultra-high performance concrete (UHPC) depends on its material ingredients and mixture proportioning, which leads to denser and relatively more homogenous particle packing Figure (1). The properties of ultra-high strength concrete improved fatigue behavior and very low porosity, leading to excellent resistance against aggressive environments [3].



Figure(1): Depiction of force transfer through :- (a- normal concrete and b- UHPC)

The mechanical properties and durability of UHPC are both much better than HPC and NC. In order to make use of the large potential of UHPC, Standards and recommendations on design and construction of the UHPC structures must be established. Designers, architects and engineers should be more open to this new material and technology. In addition, further scientific researches on UHPC and UHPC structures also must be continued. With all these efforts, UHPC may turn into a widespread 'regular' technology, thus resulting in more sustainable and durable infrastructures [4].

Research into new fiber-reinforced concretes continues today. FRC is a concrete containing fibrous material which increases its structural integrity. It contains short discrete fibers that are uniformly distributed and randomly oriented. Fibers include steel fibers, glass fibers, synthetic fibers and natural fibers – each of which lends varying properties to the concrete [5].

It is now well established that one of the important properties of steel fiber reinforced concrete (SFRC) is its superior resistance to cracking and crack propagation. As a result of this ability to arrest cracks, fiber composites possess increased extensibility and tensile strength, both at first crack and at ultimate, particular under flexural loading; and the fibers are able to hold the matrix together even after extensive cracking. The net result of all these is to impart to the fiber composite pronounced post – cracking ductility which is unheard of in ordinary concrete. The transformation from a brittle to a ductile type of material would increase substantially the energy absorption characteristics of the fiber composite and its ability to withstand repeatedly applied, shock or impact loading [6].

UHPFRC enables structural members to be built without the need of transverse reinforcement because of its advantageous flexural strength .Since UHPC can lead to longer span structures with reduced member sizes compared to normal or high strength concrete, a significant reduction in volume and self-weight would be expected with UHPC members. The cross sectional area of UHPC compressive members may be reduced compared to normal concrete members due to UHPC's high compressive strength [7].

2. XPERIMENTAL TESTING

The tests for hardened concrete included compression tests for strength and indirect tensile tests (split cylinder and flexural strength tests) The influence of the steel fibers and polypropylene fibers amounts on the compressive strength concrete together with the workability and density of UHPFRC was studied by preparing several concrete mixes. The properties of different constituent materials used to produce UHPFRC. The test procedures, details and equipment used to assess concrete properties are illustrated in the following sections

2.1 Materials

Ordinary Portland cement: is the most active component of UHPFRC and usually has the greatest unit cost and the test results comply with the requirements of the Iraqi Standard Specification IQS (No. 5/1984)[8] (Portland cement) and with the requirements of (ASTM C150) [9] specifications for comparison purposes.

Quartz Sand: aggregate is relatively inexpensive for producing UHPFRC. The nominal size ranges from (0.15 to 0.6)mm. It is important to ensure that the aggregates are clean, since a layer of silt or clay reduce the cement aggregate bond strength, in addition to increasing the water demand, results of the sand, the limits of the Iraqi Specification (No.45/1984) [10], and British Standards (B.S.) 882:1983)[11].

Silica fume: is a byproduct coming from the reduction of high-purity quartz with coal or coke and wood chips in an electric arc furnace during the production of silicon metal or ferrosilicon alloys. The silica fume, which condenses from the gases escaping from the furnaces, has a very high content of amorphous silicon dioxide and consists of very fine spherical particles (ACI-234R-96)[12]. It is extremely fine with particle size of 0.1 µm, and it exists in grey powder form that contains latently reactive silicon dioxide and no chlorides or other potentially corrosive substances. The silica fume used in this investigation conforms to the requirements of (ASTM C1240-05) [13]specifications.

Water: tap water was used in all concrete mixtures and in curing all of the tests' Specimens.

Chemical Admixtures (Superplasticizer): the chemical admixture used is super plasticizer which is manufactured to conform to (ASTM C494)[14] specification types G and F. When added to concrete blend, it improves the properties of fresh and hardened concrete, and this plasticizing impact can be used to increase the workability of fresh concrete, making it extremely powerful; and the water reduction to a great degree, resulting in high density, strength, and excellent flowing ability.

Polypropylene fibers: it belongs to the poly-Avlfynhast family. It is a plastic polymer that was developed in the middle of the 20th century where it became widely used in the construction industry in order to enhance fire resistance of concrete. It is not hydrophilic- polypropylene fibers do not absorb water as a result of malicious. These fibers are resistant to alkalis, chemicals, chloride, and heat transfer properties. Among the properties of polypropylene is that it does not absorb water, that is, polypropylene fibers do not need to bother to mix cement with water. **Table (2)** show the property of the used polypropylene in this research work.

Table (2) properties of polypropylene fibers

NO.	Property	Polypropylene
1-	Specific gravity	0.91
2-	Sulfate content	Nil
3-	Fiber diameter	38 µm
4-	Fiber length	12mm
6-	Tensile strength	320-400 MPa
7-	Melting point	160-170 ºC (320-338 F)

Steel fibers: these have a high modulus and strain to failure due to the high tensile strength and good formability; therefore, they are considered as one of the best and most economical fiber types. The steel fibers used in UHPFRC, exhibit a high tensile strength as well as to study the effect of using it in improving fire resistant for the ultra-high-performance concrete and the properties of the steel fibers are given as in Table **(**3**)**.

Table (3) properties of steel fibers

NO.	Properties	Steel fibers
1-	Length (mm)	13 mm
2-	Diameter (mm)	0.20 mm
3-	Density (gm/cm3)	7.8 g/cm3
4-	Tensile strength	655 MPa
5-	Shape	Straight

2.2 Testing program

The effect of the steel and Polypropylene fibers was studied in order to obtain the optimum percentage for the mix by preparing different mixes with different percentages of polypropylene and steel fiber shown Table(4-A,B). The effect of steel fibers and polypropylene fibers amounts on the UHPFRC properties were studied by preparing several concrete mixes. The properties of the different constituent materials used to produce UHPFRC were also discussed the details of the test's procedure. UHPFRC constituent materials used in this research included ordinary Portland cement, quartz sand, silica fume, polypropylene, and steel fibers. In addition, superplasticizer was used to ensure suitable workability. Proportions of these constituent materials have been chosen carefully in order to optimize the properties of the mixture, according to many studies.

Table (4-A) – One cubic meter components of UHPFRC mixture (Kg/m3)

Name MIX. Materiel	M.00.1	M.P0.2	M.P0.3	M.P0.4	M.0S.5	M.PS.6	M.PS.7	M.PS.8
Cement	**900**	**900**	**900**	**900**	**900**	**900**	**900**	**900**
Quartz Sand	**1125**	**1125**	**1125**	**1125**	**1125**	**1125**	**1125**	**1125**
Silica Fume	**135**	**135**	**135**	**135**	**135**	**135**	**135**	**135**
Super plasticizer	**27**	**27**	**27**	**27**	**27**	**27**	**27**	**27**
water	**216**	**216**	**216**	**216**	**216**	**216**	**216**	**216**
Polypropylene	**0**	**3.6**	**7.2**	**10.8**	**0**	**3.6**	**7.2**	**10.8**
Steel Fibers	**0**	**0**	**0**	**0**	**144**	**144**	**144**	**144**

Table (4-B) – UHPFRC Mixes Used in This Research /Cement content percentage.

Name MIX. **Materiel**	**M.00.1**	**M.P0.2**	**M.P0.3**	**M.P0.4**	**M.0S.5**	**M.PS.6**	**M.PS.7**	**M.PS.8**
Cement	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Quartz Sand	125%	125%	125%	125%	125%	125%	125%	125%
Silica Fume	15%	15%	15%	15%	15%	15%	15%	15%
Super plasticizer	3%	3%	3%	3%	3%	3%	3%	3%
water	24%	24%	24%	24%	24%	24%	24%	24%
Polypropylene	0.0%	0.4%	0.8%	1.2%	0.0%	0.4%	0.8%	1.2%
Steel Fibers	0.0%	0.0%	0.0%	0.0%	16%	16%	16%	16%

2.3 Specimens A total of (48) cubes 100 × 100 × 100 mm, and 24 prisms 100 × 100 mm cross section and 400 mm length and 24 cylinders 300mm length and 150 mm Diameter cylinders of UHPFRC specimens were cast and tested in this research Fig.(2). These UHPFRC specimens were arranged into eight groups shown as shown in Table **(4-A,B)** .These eight group cubes of UHPC, at the beginning tested the compressive strength flexural strength and tensile stresses strength .

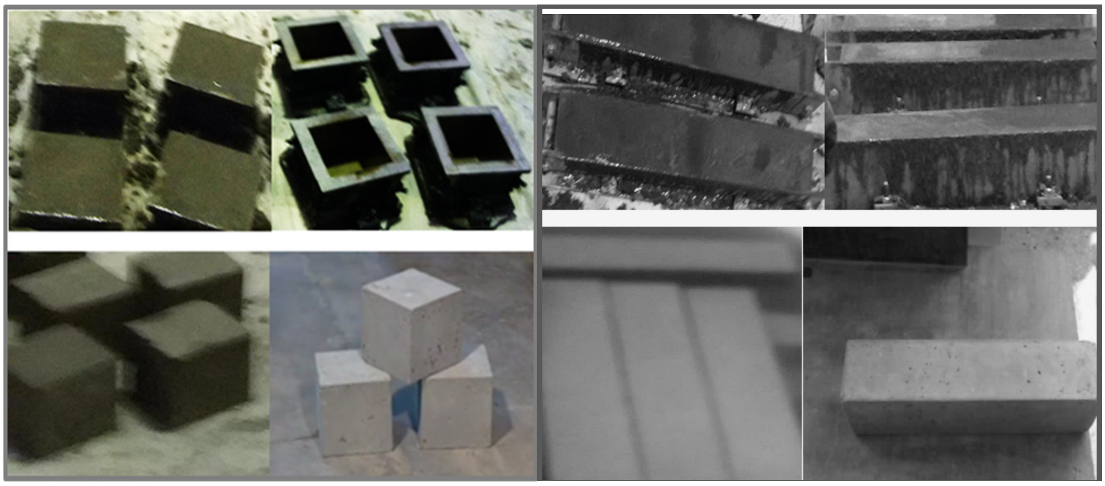


Figure (2) Cubic and Beam specimens UHPFRC used for testing

3.TESTING PROCEDURE FOR (UHPFRC)

As stated before, the aim of this research is to study the effects of adding steel and polypropylene fibers on resistance of Ultra High Performance Concrete (UHPC) using local available materials . The tests for hardened concrete included compressive flexural strengths and splitting tensile the concrete.

3.1. Compression test of UHPFRC

One of the most important tests for concrete is the compressive strength; this test was done according to the [ASTM C109, 2008 ASTM C109/C109M, 2008][15].Numerous trial mixtures were prepared For each batch of UHPFRC made, (100x100x100) mm, cubes of concrete were prepared. For each group, three samples were prepared and tested in order to obtain averaged value.

The compressive strength machine the materials Figure (3) was used for determining the maximum compressive loads carried by concrete cube specimens.

The compressive strength for the specimen σ *comp* in MPa can be calculated by dividing the maximum compressive load by the area loaded:

$$\sigma\, comp = P/A \qquad \textbf{Eq. (1)}$$

Where: P = maximum load carried by the cube specimen during the test.
A = the cross sectional area of the specimen.

Figure (3): The compressive strength machine the concrete

3.2. Splitting cylinder test of UHPFRC

The splitting tensile strength of UHPFRC was measured based on (ASTM C496. 2004)[16] Standard test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens. Indirectly measures the tensile strength of concrete by compressing a cylinder through a line load applied along its length. .

Specimen induces tensile and shear stresses on the aggregate particles inside the specimen, generating the bond failure between the aggregate particles and the cement paste. Usually, splitting tensile strength test is used to evaluate the shear resistance provided by concrete elements.

The tensile strength of concrete is evaluated using a split cylinder test, in which a cylindrical specimen is placed on its side and loaded in diametrical compression, so to induce transverse tension. Practically, the load applied on the cylindrical concrete specimen induces tensile stresses on the plane containing the load and relatively high compressive stresses in the area immediately around it. When the cylinder is compressed by the two plane-parallel face plates, situated at two diametrically opposite points on the cylinder surface then, along the diameter passing through the two points, the major tensile stresses are developed which, at their limit, reach the fracture strength value ASTM C496 indicates that the maximum fracture strength can be calculated based on the following equation.

$$Fsp=2P/\pi DL \qquad \text{Eq.(2)}$$

Where: **P:** is the fracture compression force acting along the cylinder;
D: is the cylinder diameter;
π =3.14
L: is the cylinder length.

3.3. Flexural test of UHPFRC

The flexural strengths of concrete specimens were determined by the use of simple beam with center point loading in accordance with [**ASTMC293**, **ASTM C293/C293M, 2010**][17]Numerous trial mixtures were prepared. For each batch of UHPFRC made, (100x100x400) mm, prisms of concrete were prepared. For each group, three samples were prepared and tested in order to obtain averaged value.

The specimen is a beam (100 x 100 x 400) mm, the mold is filled in one layer, without any compacting or rodding, and then immersed in water at 25ºC. The cast beam specimens are tested turned on their sides with respect to their position as molded. This should provide smooth, plane and parallel faces for loading if any loose sand grains or incrustations are removed from the faces that will be in contact with the bearing surfaces of the points of support and the load application, Figure (4).

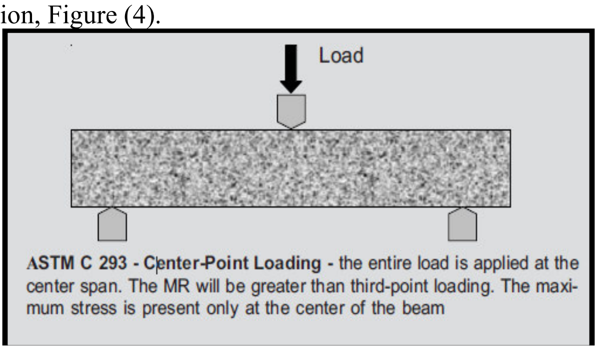


Figure (4): Flexural strength testing (ASTM C293)Figure

The pedestal on the base plate of the machine is centered directly below the center of the upper spherical head, and the bearing plate and support edge assembly are placed on the pedestal. The center point loading device is attached to the spherical head. The test specimen is turned on its side with respect to its position as molded and it is placed on the supports of the testing device. This provides smooth, plane, and parallel faces for loading. The longitudinal centerline of the specimen is set directly above the midpoint of both supports. If full contact is not obtained between the specimen and the load applying or the support blocks so that there is a gap, the contact surfaces of the specimen are ground. The specimen is loaded continuously and without shock at until rupture occurs.

Finally, the maximum load indicated by the testing machine is recorded.

The flexural strength of the beam, **Fr** (in MPa), is calculated as follows:

$$Fr =3PL / 2bd^2 \qquad \text{Eq. (3)}$$

Where: P = maximum applied load indicated by the testing machine,
L = span length, b = average width of specimen, at the point of fracture,
d = average depth of specimen, at the point of fracture.

All beam specimens were tested after 28 days from casting. Three beams were tested for each patch, the mean values of the specimens were considered as flexural strength of the beam. All concrete samples were placed in curing basin after 24 hours from casing. All samples remained in the curing basin up to time of testing at the specified age. The curing condition of lab basin followed the (ASTM C192, 2008). Curing water temperature is around 25C.

4. EXPERIMENTAL RESULTS TESTS AND DISCUSSION OF (UHPFRC)

Laboratory tests were conducted to evaluate and study the hardened properties of Ultra- High Performance Fiber Reinforced Concrete (UHPFRC). Mean results for concrete mixtures at ages (7and 28) days are summarized in the tables and figures. Results are the unit weight, compressive strength , Flexural strength and splitting tensile strength tests.

4.1 Compressive strengths for samples

The results shown Compressive strengths for samples of Ultra- High Performance Fiber Reinforced Concrete (UHPFRC) as in the Table (5) shown below:-

Table (5): Compressive strengths for samples

Name Mix.	Polypropylene Fibers %	Steel Fibers %	Unit weight (kg/m3)	Compressive strengths (MPa)	
				7 days	28 days
M.00.1	0.0%	0.0%	2335.3	82.34	140.05
M.P0.2	0.4%	0.0%	2326.1	95.55	150.25
M.P0.3	0.8%	0.0%	2321.4	99.75	154.75
M.P0.4	1.2%	0.0%	2316.5	102.22	160.45
M.0S.5	0.0%	16%	2396.2	96.66	163.75
M.PS.6	0.4%	16%	2378.7	104.87	167.49
M.PS.7	0.8%	16%	2366.3	108.67	170.32
M.PS.8	1.2%	16%	2348.4	110.45	161.95

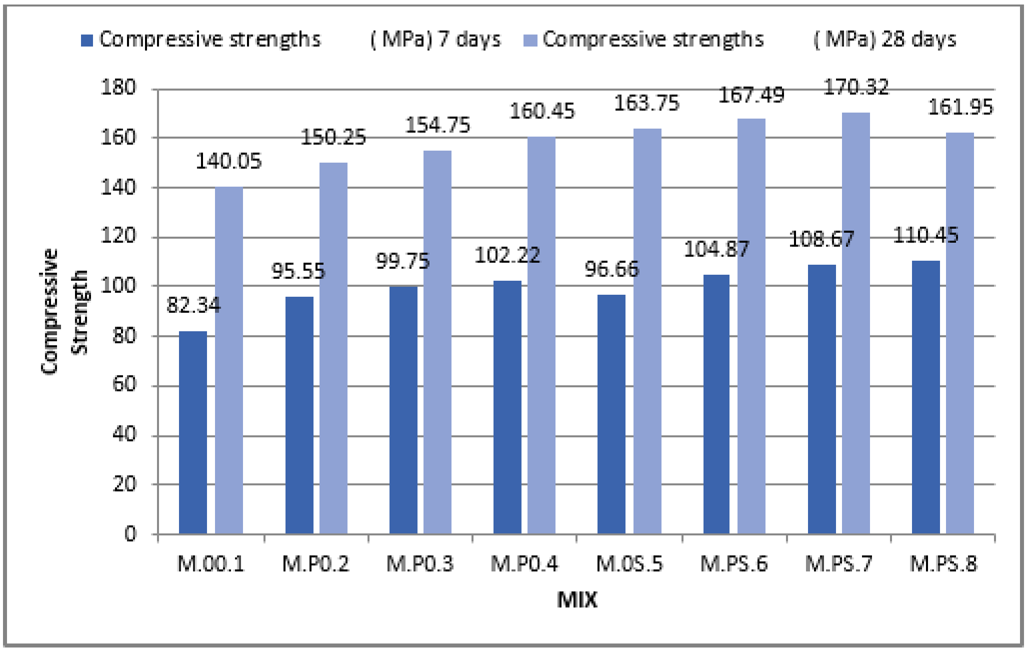


Figure (5): Compressive strengths for samples (7 and 28 days)

Results shown in Table (5) and Figure (5) demonstrate that it is possible to develop Ultra-High Performance Fiber Reinforced Concrete (UHPFRC) with different polypropylene and steel fibers amounts in the 7 and 28 days age.

It can be observed that increasing the polypropylene content from (0.4% to 0.8% to 1.2%) effectively increases the compressive strength of concrete more than when it was used alone without fibers polypropylene.

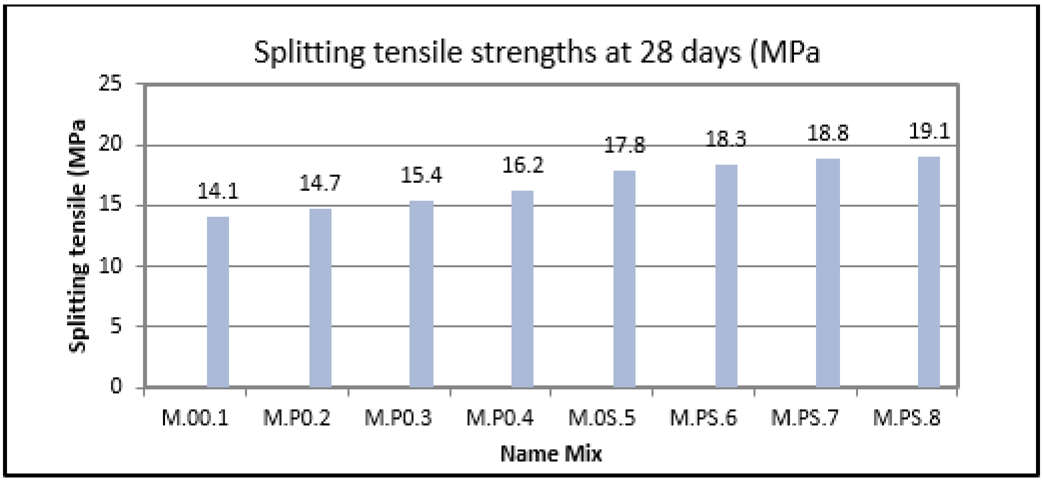
It is noticed the compressive strength for mix without fibers (Mix.001) were increased by 7.3% when 0.4% polypropylene is used, by 10.5% when 0.8% polypropylene is used, and by 14.5 % when 1.2% polypropylene is used, when steel fiber 0% is used. On the other hand it is noticed the compressive strength for mix without fibers (Mix.001) were increased by 19.5 % for 0.4% polypropylene and 16% steel fibers ,by 21.6 % for 0.8% polypropylene and 16% steel fibers ,and 15.6% for 1.2% polypropylene and 16% steel fibers. On the other hand the compressive strength increased by 16.9% when 16% steel fibers is used only. From the above It was observed that adding the optimum percentage of steel fibers by (16%) and polypropylene fiber (0.8%) increases effect the polypropylene and steel fibers on compressive strength of UHPFRC, It gives the best results in the compression-resistant Ultra-High Performance Fiber Reinforced Concrete.

4.2. Splitting Tensile strengths for samples

From Table (6) and Figure (6) it can be stated that the larger is the steel fiber amount, the larger is the splitting tensile strength. The obtained results can be justified as, the addition of steel fibers and Polypropylene Fibers with the tensile strength, distributed homogenously within every batch will sustain the developed tensile stresses, thus increase the splitting tensile strength of specimens. Finally, the above results show that mixtures can achieve a mean splitting tensile strength of concrete specimens of 19.1 MPa at an age of 28 days.

Table (6): splitting tensile strengths for samples

Name Mix.	Polypropylene Fibers	Steel Fibers	Splitting tensile strengths (MPa) 28 days
M.00.1	0.0%	0.0%	14.1
M.P0.2	0.4%	0.0%	14.7
M.P0.3	0.8%	0.0%	15.4
M.P0.4	1.2%	0.0%	16.2
M.0S.5	0.0%	16%	17.8
M.PS.6	0.4%	16%	18.3
M.PS.7	0.8%	16%	18.8
M.PS.8	1.2%	16%	19.1



Figure(6): splitting tensile strengths for samples (28 days)

It is can be observed that increasing the polypropylene content from (0.4% to 0.8% to 1.2%) effectively increases the splitting tensile strengths of concrete when it was used alone without fibers polypropylene. Also it was observed that adding of steel fibers by 16% effectively increases the tensile strengths of concrete .

It is noticed the splitting tensile strengths for mix without fibers (Mix.001) were increased (4.%,9.2%,and 14.9%) when used (0.4%,0.8% ,and 1.2%) polypropylene and 0% steel fibers is used, and by (29.8 %,33.3%,and 35.4%)when (0.4%, 0.8%, and 1.2%) polypropylene and 16% steel fibers is used. Also it is noticed that where the tensile strength increased by (26.2%) when (16%) steel fibers and 0% polypropylene fiber is used.

The optimum percentage of polypropylene and steel fibers recommended to be used based on this investigation for improving the concrete resistance is 1.2% polypropylene and 16% steel fibers percentage of the cement used.

4-3 Flexural strengths for samples

Results shown in Table (7) and Figure (7) demonstrate that it is possible to develop UHPFRC with different polypropylene and steel fibers amounts.

Table (7): Flexural strengths for samples .

Name MIX.	Polypropylene Fibers %	Steel Fibers %	Flexural strengths at 28 days (MPa)
M.00.1	0.0%	0.0%	14.28
M.P0.2	0.4%	0.0%	15.62
M.P0.3	0.8%	0.0%	16.82
M.P0.4	1.2%	0.0%	19.01
M.0S.5	0.0%	16%	21.65
M.PS.6	0.4%	16%	22.86
M.PS.7	0.8%	16%	23.54
M.PS.8	1.2%	16%	22.01

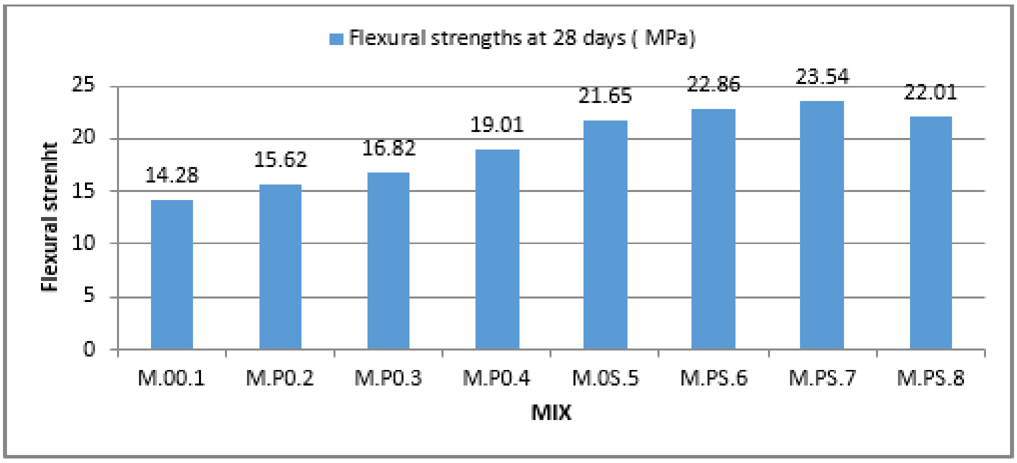


Figure (7): Flexural strengths for samples

It is can be observed that increasing the polypropylene content from (0.4% to 0.8% to 1.2%) effectively increases the flexural tensile strengths of concrete when it was used alone without fibers polypropylene. Also it was observed that adding of steel fibers by 16% effectively increases the tensile strengths of concrete .

It is noticed the Flexural tensile strength for mix without fibers (Mix.001) were increased (9.3%,17.7%,and 33.1%) when used (0.4%,0.8% ,and 1.2%) polypropylene and 0% steel fibers is used, and by (60.0 %,64.8%,and 54.1%)when (0.4%, 0.8%, and 1.2%) polypropylene and 16% steel fibers is used. Also it is noticed that where the tensile strength increased by (51.6%) when (16%) steel fibers and 0% polypropylene fiber is used.

The optimum percentage of polypropylene and steel fibers recommended to be used based on this investigation for improving the concrete resistance is 0.8% polypropylene and 16% steel fibers percentage of the cement used.

4.4 Effects of polypropylene and steel fibers on unit weight concrete

Table (8) and Figure (8) summarize the effect of polypropylene and steel fibers on the concrete unit weight. The results show that the density of concrete decreases when increasing the polypropylene fiber percentage in mix, but it increases when the amount of steel fibers increases.

Table (8): Concrete unit weight for samples .

Name MiX .	Polypropylene %	Steel Fibers %	Unit weight (kg/m3)
M.00.1	0%	0%	2335.3
M.P0.2	0.4%	0%	2326.1
M.P0.3	0.8%	0%	2321.4
M.P0.4	1.2%	0%	2316.5
M.0S.5	0%	16%	2396.2
M.PS.6	0. 4%	16%	2378.7
M.PS.7	0.8%	16%	2366.3
M.PS.8	1.2%	16%	2348.4

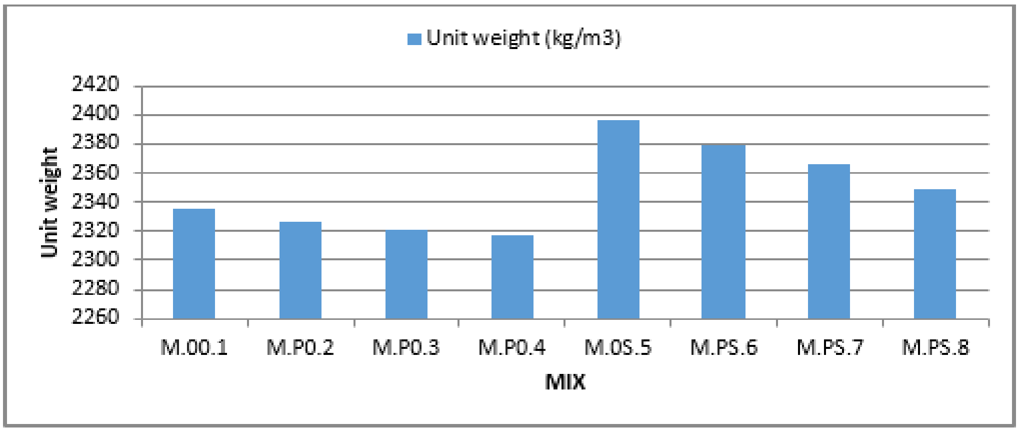


Figure (8): Unit weights for samples

5.Conclusions

Ultra-High Performance Fibers reinforced Concrete (UHPFRC) is a relatively new form of concrete which can be used for general applications and especially for rehabilitation works. The main advantages that UHPFRC have over standard concrete are its high compressive strength, relative high tensile and flexural strength, low porosity, high durability .The objective of this research is to study the effects of adding available materials to the concrete mixes and designing these mixes with optimum amount of polypropylene and steel fibers on resistant of Ultra High Performance Concrete (UHPC) occurrence of failure. The experimental phase of this research focused on developing UHPFRC and properties for hardened statuses.

1. Experimental results show the significant improvement of the residual mechanical properties of UHPFRC containing the mix of fibers (polypropylene and steel fibers) compared to UHPC without fibers
2. The results show that the density of concrete decreases when increasing the polypropylene fiber percentage in mix, but it increases when the amount of steel fibers increases while keeping other contents constant.
3. It is possible to develop UHPFRC with steel fibers and polypropylene fibers contents. For steel fibers content is 16% and polypropylene fibers 0,8% by the total weight of cement produced very high compressive strength concrete with 170.32 MPa, and Flexural strength concrete with 23.54 MPa
4. When the steel fibers amount increases, the compressive strength increases also as the compressive strength increases the splitting cylinder strength also increases at certain cases of contents for the UHPFRC and as known in the normal concrete.
5. The larger the steel fiber and polypropylene fibers content, the larger the splitting tensile strength when used steel fibers content is 16% and polypropylene fibers 1,2% by the total weight of cement. high splitting tensile strength concrete with 19.1 MPa because it is works as reinforcement sustaining some of the developed tensile stresses .
6. Flexural strength increases as the polypropylene fibers and steel fibers content increases, because the added fibers, works as a reinforcement sustaining some of the developed tensile stresses.
7. From the above it was observed that adding the optimum percentage of steel fibers by (16%) and polypropylene fiber (0.8%) increases effect the polypropylene and steel fibers on compressive strength and flexural tensile strength of concrete and it gives the best results in the resistant of UHPFRC.

NOTATION

PP.F	Polypropylene fibers
S.F	Steel fibers
NSC	Normal Strength Concrete
HSC	High Strength Concrete
SHSC	Super High Strength Concrete
UHPC	Ultra- High Performance Concrete
UHPFRC	Ultra-High Performance Fiber Reinforced Concrete
M.00.1	Mixing number one without Polypropylene (0%) and steel fibers (0%)
M.P0.2	Mixing number two with Polypropylene (0.4%) and Steel fibers (0%)
M.P0.3	Mixing number three with Polypropylene (0.8%) and Steel fibers (0%)
M.P0.4	Mixing number four with Polypropylene (1.2%) and Steel fibers (0%)
M.0S.5	Mixing number five with Polypropylene (0.0%) and Steel fibers (16%)
M.PS.6	Mixing number six with Polypropylene (0.4%) and Steel fibers (16%)
M.PS.7	Mixing number seven with Polypropylene (0.8%) and Steel fibers(16%)
M.PS.8	Mixing number eight with Polypropylene (1.2%) and Steel fibers (16%)

Note : On behalf of all authors, Ammar O. AL-Mwanes that there is no conflict of interest.

5. References

[1] M. Arafa, S. Shihada, and M.karmout,(Mechanical Properties of Ultra High Performance Concrete),Asian journal of material science,(2010),ISSN,1996-3394 Malay.
[2] ACI Committee ACI 363R-92, 2003, "State-of-the-Art Report on High-Strength Concrete," ACI Manual of Concrete Practice part 5.
[3] S. Abbas, M. Nehdi, and M. A. Saleem,(Ultra-High Performance Concrete Mechanical Performance Durability Sustainability and Implementation Challenges), International Journal of Concrete Structures and Materials, (2016),Vol.10, No.3, pp.271–295.
[4] GU ChunPing , YE Guang& SUN Wei (Ultrahigh performance concrete–properties, applications and perspectives), Science China ,Technological Sciences, Materials Science & Engineering, Southeast University, Nanjing 211189,(2015), Vol.58 No.4: 587–599.
[5] Ikai, S., Reichert, J. R., Rodrigues, A. V., and Zampieri, V. ,(Asbestos-free technology with new high

toughness polypropylene fibers in air-cured Hatschek process).Journal of Construction and Building Materials,(2010), Vol. 24(2), pp 171–180.

[6] Colin D. Johnston,(Fiber reinforced cements and concretes Advances in concrete technology) , volume 3 – Gordon and Breach Science publishes.

[7] Thomas L. VandeVoort, (Design and Field Testing of Tapered H-shaped Ultra High Performance Concrete) , (2008) , Retrospective Theses and Dissertations. Paper 15388. pp 60-62.

[8] IQS (No. 5/1984), (Portland Cement,) Central Agency for Standardization and Quality Control, Planning Council, Baghdad, Iraq, translated from Arabic edition 1984, 4 pp.

[9] ASTM C150, 2004, "Standard specification of Portland cement American Society for Testing and Materials Standard Practice C150", Philadelphia, Pennsylvania.

[10] IQS (No. 45/1984), "Aggregate from Natural Sources for Concrete" Central Agency for Standardization and Quality Control, Planning Council, Baghdad, Iraq, translated from Arabic edition 1984, 3 pp.

[11] B.S. (882-1983), "British Standard Specification for Aggregate from Natural Sources for Concrete," 1983, 23 pp.

[12] ACI committee 234(ACI-234R-96), "Guide For Use of Silica Fume in Concrete", ACI Manual of Concrete Practice, Part1, 1996.

[13] ASTM C 1240 – 05, "Standard Specification for Silica Fume Used in Cementitious Mixtures", Annual Book of ASTM Standards, American Society for Testing and Materials, Vol. 04-02, 2007, pp.1-8.

[14] ASTM C494-04, "Standard Specification for Chemical Admixtures for Concrete", Annual Book of ASTM Standards, American Society for Testing and Materials, Vol. 04-02, 2007, pp.1-9.

[15] ASTM C109 / C109M, "Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens)", American Society for Testing and Materials Standard Practice C109,Philadelphia, Pennsylvania.

[16] ASTM C496, 2004, “Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens”, American Society for Testing and Materials Standard Practice C496, Philadelphia, Pennsylvania.

[17] ASTM C 293-02, "Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with One Point Loading", Annual Book of ASTM Standards, Vol.04.02, Concrete and Aggregates, West Conshohocken, United State, 2002, 3p.