Influence of Hybrid Fibers on the Fresh and Hardened Properties of Structural Light Weight Self-Compacting Concrete

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Abstract. The scope of this research is certainly to provide some experimental data on the effect of hybrid fiber on fresh and hardened properties of structural pumice lightweight aggregates self-compacting concrete (SLWSCC). Addition of hybrid fibers to concrete properties has changed the state of concrete from brittle to ductile. Slump flow test, L-box test, and V-funnel test were leading to find the (SLWSCC) workability of fresh properties. The mechanical properties of hardened (SLWSCC), including compressive, and splitting tensile, strengths, and moduli of rupture. Eleven concrete mixtures of (SLWSCC) with different mono and hybrid fibers contents of steel fibers (SF) and polypropylene (PP) fibers with a ratio (0%, 0.3%, 0.6%, and 1.2%) of volume fractions were prepared to study the change in its fresh and hardened characteristics. Test results were showed that the fibers whereas used in a hybrid form with (SLWSCC) be able to have as a result of high composite performance compared to their single thing fiber-reinforced concretes. The optimum properties of (SLWSCC) can get form mix (HF8) with 0.6% (SF) content and 0.3% (PP) fibers exhibit higher flexural strength behavior by 206%, and tensile strength of increased by 129%.

1. Introduction

Structural engineers and design codes have generally recognized the ductile behavior of concrete structures exposed to seismic activity, these comments confirm the utility that hybrid fibers share to the ductility of self-compacting lightweight aggregate concrete which is be considered as brittle [1]. Subsequently, high economical and qualified a way to solve a problem by blending both pumice lightweight aggregate with hybrid fibers in the mixtures of concrete. That will result in a decrease dead load and improving the ductile behavior for all form of burdening. Farther investigate is required to optimise the mix portions and in the addition to inspect the influence of hybrid (PP and steel) fibers on the additional characteristics of concrete with lightweight aggregate e.g. durability, strength, creep, etc. [2].

Structural lightweight aggregate self-compacting concrete (SLWSCC) properties excellent in segregation resistance, filling the reinforcement formwork without any outward effort consolidation, and flowability for concrete according to European Federation for Specialist Construction Chemicals and Concrete Systems (EFNARC) [3], also with its benefits of decreasing the structures dead weight with lessening the cross section of members.[4].

Structural concrete of light weight aggregate has compressive strength of 17 MPa at 28 days and 1120–1920 kg/m$^3$ density, As per ACI committee report[5], self-compacting concrete (SCC) includes more filler amounts like (e.g. limestone powder, blast furnace slag ,silica fume, fly ash, and etc.) and superplasticizers to increasing its workability [6].

Strengthening hybrid Fibers to (SLWSCC) has increased in the ductility of structures because the hybrid fibers at concrete may develop the mechanical properties of (SLWSCC) besides the sudden
loading and control cracks [7]. Utilize of fibers at self-compacting concrete mixtures has been presented by many investigations [8], [9].

Many studies deal with hybrid steel fibers addition to (SLWSCC), focalization on end fibers but restricted researches have been conducted on straight fibers that probably has lesser effect for concrete workability particularly on self-compacting concrete [10], [11]. Results of study using polypropylene 0.3% of these fibers decrease the flowability for 720 mm to 430 mm, and decreases flow of slump for 0.1% and 0.2% of fiber use are 680 mm, and 560 mm, successively [12]. J. Alexandre Bogas et al. in 2012 demonstrated fibers in common effect reducing of workability and flow for whole the mixes Light weight self-compacting concrete like to conventional concrete weight with the addition of fibers in improving the impact resistance and control on cracks progressive [4]. Reversely results are described the fibers influence on concrete compressive strength, shows there is no importance impact of fibers of steel adding for the elasticity modulus and strength of compressive for (SHLSCC) and about 12% decreasing at compression strength [11]. According to the research conducted by Nicolas Ali Libre et al. in 2011 using hybrid fibers, the polypropylene fibers have no effect on compressive strength of concrete and also be concluded that the addition of steel fibers up to 0.5% of concrete volume improved the compressive strength of concrete by about 47% up to 1% of concrete volume was not so effective and no further strength increment was observed.

Increasing at the modulus of rupture and tensile strength for (SLWSCC) with the fibers addition has been studied by many researchers. Shahid Iqbal et al. in 2015 demonstrated 110% and 37% increase in flexural strength and splitting tensile strength successively for increased fibers of steel to 1.25%. The used polypropylene fibers and fibers of nylon at concrete of oil palm shell increase of 86% at the feluctural strength [12]. Excellent ductility and greater loads in cracking limit were observed for hybrid fibers comparison with mono fibers. This shows that, if hybrid steel fibers are utilized on SCC, it will connect the influence of together to generate concrete with higher ductility and the self-weight will reduce when using lightweight concrete [13].

2. Materials

Ordinary Portland cement is used, bring at Al- Douh refectory, associated with standers ASTM C150-02 [14]. Pumice was used to prepare for the (SLWSCC) mixtures. The quarry of this stone occurs in the north of Iraq in AL- Sulaymania governorate. Pumice stone has a dark color, high permeability, and low-density, porous form of vitrified volcanic rock and high silicon oxide (SiO2). Crushed Pumice stone was used as a coarse lightweight aggregate of nominal size (12.5 - 4.75) mm for that work. Pumice segments were fractured manually blended and graded as per the ASTM C330-04 [15]. Table (1) illustrates the physical properties. Al-Ukaider natural sand was used as fine aggregates with fineness modulus of 2.86 passing through 4.75 mm sieve, the specific gravity of 2.65. Results indicate that the sand is within the requirements of the ASTM C33-97 [16].

Table (2) shows the physical and technical properties of fibers used in this work. Two types of macro hooked steel fibers (SF) with aspect ratio of 80 and Polypropylene fiber (PPF) with aspect ratio 677 complied with requirements of ASTM C1116-02 [17]. To perform satisfactory workability at self-compacting concrete, a superplasticizer (SP) base on polycarbonate according to ASTM (C494) (type F) [18], specification has a density of total solid content of 41% and 1.10 g/cm³ a was employed.

| Materials         | Size         | Loose bulk density kg/m³ | Specific gravity | Water absorption % |
|-------------------|--------------|--------------------------|------------------|--------------------|
| Coarse aggregate  | 2.36-12.5    | 574                      | 2.51             | 6.2                |
| Fine aggregate    | 0- 4.75      | 423                      | 2.65             | 0.75               |
Table 2. Properties of fibers.

| Property        | Steel Fiber SF | Polypropylene fibers (P.P.F) |
|-----------------|----------------|-----------------------------|
| Density (Kg/m³) | 7880           | 7900                        |
| Tensile strength (MPa) | 1100    | 360                         |
| Diameter (mm)   | 0.5            | 0.018                       |
| Length (mm)     | 22             | 12                          |
| Geometry        | hooked         | Fibrillated                 |
| Aspect ratio    | 80             | 677                         |

3. Methodology
The techniques ways of this study to evaluate the changing in the characteristics of (SLWSCC) with the increment of hybrid fibers. The mix design was made to conform to the requirement of structural Lightweight aggregates concrete, according to AC1 Committee 213 classification [5], with reference concrete mixture (HF0) to give a (20 MPa) at 28-day. To define the workability of (SLWSCC) was used slump flow test and T500 time. L-box test was used to measure the passing ability of SCC with different properties such as flowability, and segregation of the concrete. The V-funnel test indicates the period of a defined volume of SCC needs to pass a narrow opening and is reported to the plastic viscosity. All these tests were conducted in accordance with the EFNARC [3]. The properties resultants of fresh (SLWSCC) used for this work are presented in Table (4) and as shown in Figure (1). The density of concrete is entirely a cylinder of determined weighing and volume it also, air content was computed according to ASTM C138 [19].

Hardened properties of concrete tests according to testing of ASTM standard, three-cylinder samples of height of 200 mm and a diameter of 100 mm were each casted to test the compression strength (ASTM C39) [20], during 7 and 28 days of the treatment period, splitting tensile strength (ASTM C496) [21]. After 24 h of casting, the cylinder samples were taken off from the molds and hold at the water for curing according to ASTM C192 [22], until the day of testing. Two (100X100X400mm) prisms for strength of flexural (Modulus of Rupture) for (28) day, correspondent to ASTM (C78–98) [23].

4. Experimental program
To investigate the effect of hybrid fibers (HF) (PP and steel fibers) mixtures at the characteristics of (SLWSCC), eleven mixes were prepared; one mixture without fibers was prepared as reference mix (HF0) and three mixes with only steel fibers of varied volume fraction between 0% and 1.2% of (SLWSCC) and three mixes with just PP fibers with the same varied of volume fraction, the last four hybrid fibers mixes of varying volume were made, all eleven mixes are outlined at table (3). Overall parameters e.g. the content of cement (c = 490 kg/m³), the content of water (300 Kg/m³), the superplasticizer dosage (about 3.5% of cement weight.), the coarse aggregates (740 Kg/m³) and fine aggregates (450Kg/m³) were held fixed at all mixes. The absorption water of aggregates through mixing time was watched and the batch ratios were regulated accordingly. For the self-compacting concretes containing hybrid fibers, the superplasticizer dosage was added properly to kept excellent workability.

Pumice aggregates (coarse) and fine sand were mixed at beginning with a dry case to one minute. After that, cement was entertained to the mix, the fibers were added and overall materials were mixed for 2 minutes, and the without interruption addition of fibers, hard work was made for the avoidance of fibers to obtain clumped. In the end, the needed a quantity of a specific mixture to have within water and superplasticizer was not fast added to the mixer, the mixing was nonstop for 3 minutes.

After filling up the molds, the concrete samples were to become strong using a vibrating table for a period of 8 to 12 seconds. The samples were maintained in the laboratory for 24 hours and were stored in the water for a constant 20±2 °C for 7 and 28 days, up to a time the day of the testing.
Table 3. Fibers percentage of all mixes

| Mix No. | Steel Fibers % | PP Fibers % |
|---------|----------------|-------------|
| RF0     | 0.0            | 0.0         |
| HF1     | 0.3            | 0.0         |
| HF2     | 0.6            | 0.0         |
| HF3     | 1.2            | 0.0         |
| HF4     | 0.0            | 0.3         |
| HF5     | 0.0            | 0.6         |
| HF6     | 0.0            | 1.2         |
| HF7     | 0.3            | 0.3         |
| HF8     | 0.6            | 0.3         |
| HF9     | 1.2            | 0.3         |
| HF10    | 1.2            | 0.6         |

Figure 1. L-box test, slump flow test, and V-funnel test of (SLWSCC)

5. Result and Discussion.

5.1. Rheology of fresh (SLWSCC).

Table 4 shows the fresh test resultants of (SLWSCC) with percentages of varied types of fiber, they reduce slump flow admirably, and it was diameters of all mixtures were in the range of 450–790 mm. Figure 2 indicates the flow slump test evaluates like a consequent of fibers type and ratio, slump flow of (SLWSCC) was decreased when percentage ratio of steel and polypropylene fibers are increased in comparison with reference mixture (RF0). It can be observed that the use of 0.0% - 1.2 % fibers of steel and PP fibers reduced the slump flow by 8.22% and 43.63% respectively. Table 3 and figure 3 concluded that an increase in hybrid fiber volume decreases workability all concrete mixtures comparing to reference mixture (HF0) without fibers, like substantiated for other studies [24],[6]. That result due to addition inner strength to discharge owing to the fiber. For workable the mix; the spacing of fiber must be lessen to low the permissible size [6]. This may be carry out with using small fibers, such as steel fibers (l=20mm), and a higher dose of superplasticizer (SP). Those fibers may supply bridge over to the micro-cracks before they reach the urgent crack zone. Even within steel fibers have not good influences on workability, but sufficient workability with this ratio of fibers was gained [25].

With inequality, the (HF8) mix show excellent flowability with 0.6% steel fibers and 0.3% of polypropylene fibers increased the slump flow value from 500 mm to 690 mm, compared with (HF7) mix. That result is supported by previous study [26], where the steel fibers may enhance the flowability of the mixtures.

As presented in Fig. (4), test results for V-funnel and T500 Time was increased where the steel and PP fibers are added, and the viscosity decreased, the ratio of steel fiber rise has resulted in high viscose mixtures as the (HF1), (HF3), mixtures of 0.3% and 1.2% with no PP fibers. On the contrary, the V-funnel time was low with the addition 0.6% of the fibers as (HF2). When the polypropylene fibers volume percentages were raised, also V-funnel and t500 Times increased at (HF4), (HF5), and (HF6).

The test of L-box was employed to define the concrete passability, and it is affected by the fiber incorporation, and (SLWSCC) display a conflict at L-box test heights as the content of fiber increases.
For the mixture of concrete at a content of fiber 1.2%, heights of L-box test dropped below 0.8 mm that was the least necessary. Therefore, to raise the workability, water–cement ratio and powder content were somewhat increased. In addition, it can be noted at the table that in spite of the in addition to fibers of steel that are very heavier, the fresh concrete density kept almost fixed due to the raise in content of air.

The vary in air content and workability of overall the eleven mixtures are presented on Figure (5), with the increasing at content of steel fiber, the reducing in workability will occur when the content of air raises particularly for content of steel fiber more than 1.2%.

The followed/passing ability of a hybrid mixture counts on the dosages and kinds of fiber and on the intersection and cooperation characteristics between varied types of fiber [27], collecting different types of fiber (as in the mixtures of hybrid) can remove clustering of fiber and give high workable Self compacting concrete, that extraction was certain by the well followability/passing ability for (HF7) mixture of 720mm slump flow and 4.32 sec., and (HF8) of 740mm and 3.98 sec. The better performance of these mixtures can be ascribed to the incorporated influence of the ideal dosage of Polypropylene fiber (0.3%) and the upper steel fiber volume (0.6%). Flowability is influence by means of the variations at stiffness of fiber, the geometric properties, and mechanical of fibers [28].

### Table 4. Fresh properties of all mixes.

| Mix type | Slump flow (mm) | $T_{500}$ (s) | V-funnel (s) | L-box $H_2/H_1$ | Air content (%) |
|----------|-----------------|---------------|-------------|-----------------|-----------------|
| HF0      | 790             | 3.5           | 6.5         | 0.8             | 2.75            |
| HF1      | 720             | 4.0           | 7.0         | 0.9             | 3.25            |
| HF2      | 700             | 4.5           | 8.5         | 0.95            | 3.75            |
| HF3      | 730             | 3.80          | 7.2         | 0.85            | 4.15            |
| HF4      | 680             | 4.60          | 9.5         | 0.95            | 3.7             |
| HF5      | 600             | 4.80          | 11.5        | 0.72            | 4.24            |
| HF6      | 550             | 5.0           | 12.0        | 0.75            | 6.67            |
| HF7      | 500             | 5.6           | 12.5        | 0.6             | 3.85            |
| HF8      | 690             | 6.2           | 13.0        | 0.5             | 3.25            |
| HF9      | 500             | 5.6           | 12.5        | 0.6             | 7.56            |
| HF10     | 450             | 6.2           | 13.0        | 0.5             | 7.54            |

**Figure 2.** Slump flow of (SLWSCC) with fibers ratio percentage
Figure 3. Slump flow of (SLWSCC) for hybrid fibers mixes.

Figure 4. Slump flow and v-funnel times of (SLWSCC) vs fibers ratio.

Figure 5. L-box of (SLWSCC) vs fibers ratio.
5.2. Hardened properties results.

5.2.1 Bulk density

All results of hardened bulk densities (SLWSCC) are summarized in Table (5) and figure (7), that were measured at 28 days. It was found that the density result of polypropylene fiber has not significant influence at the density of (SLWSCC) samples, while the density of concrete is chiefly influenced by the inclusion of steel fibers. The reference density of (SLWSCC) that containing no fibers were 1750 kg/m$^3$, with the addition of 0.3% - 12% steel fiber, the density of concretes were increased 3.43%, 4.0%, and 5.14% respectively compared with reference mixture, because the more steel fibers specific gravity, in the type of lightweight concrete increasing. The influence fibers steel on growing the concrete density samples more significant at the type of lightweight concrete in that reduction density was very significant. For hybrid fibers mixture, the hardened density increased with steel fibers content, with 0.6% of steel fibers and 0.3% of PP fibers in (HF8) has a higher density of 1846 Kg/m$^3$.

![Figure 6. Air content of all (SLWSCC) mixes with hybrid fibers.](image)

![Figure 7. bulk density of all (SLWSCC) mixes.](image)

5.2.2 Compressive Strength.

Compression properties are listing at Table 4 and Figure 8, which contain strength of compression at 7 and 28 days for, steel (SF) with polypropylene (PP) fibers. The steel fibers with 0.3% and 0.6% ratio in (HF1) and (HF2) were increased the compressive strength about 2.4% and 6.23% respectively as compared with reference concrete (HF0) at 28-days. The PP fibers slightly enhance the compression resistance of (SLWSCC) in comparison with reference concrete, with increases volume fraction to 0.6% slightly better the compressive strength by about 1.13%, at 7-days and 1% at 28-days respectively. On the one hand, the utilize of 1.2% or high of either steel fibers or PP fibers would reduce the compressive strength by about (11.3%), and (16.78%) respectively comparing to reference.
mix (HF0) as shown in the (HF3) and (HF6) mixtures because of become very hard and not completely compacted by weight self [24][29].

For Figure (9) shown the results of hybrid fibers mixes at 7-days and 28-days, the compression resistance improvement of about 15.82 % at (HF8) of 0.6% steel fibers with 0.3% of PP fibers was compared to (HF0), and 26.36% as compared to (HF7) mix of 0.3% hybrid fibers, that because of the actuality that hybrid fibers with that sizes and types would offer varying strength condition. Furthermore, this condition as a result of the improvement of the mechanical bond strength when the fibers both allow the ability to delay the micro-crack forming and to detain their diffusion afterwards up to a certain extent [6]. For hybrid fibers mix (HF8), the compressive strength of increased by 12% when excessed the steel fibers to 0.6% with no addition of PP fibers as to (HF7) mix, because hybrid fibers with that types and sizes will make an offer disaccorded strength condition. moreover, that case can be assigned to the enhancement the mechanical bond resistance, as the fibers togher allow the ability to delaying the microcracks forming and to detain their diffusion subsequently up to a particular scale [6].

Addition high steel fibers up to 1.2% the volume of concrete was not more efficient and no to greater resistance growth, was observed.

Table 5. Results of mechanical properties of (SLWAC) samples with hybrid fibers.

| Mix Type | Average Bulk density (kg/m³) | Comp. Strength 7 - days MPa | Comp. Strength 28 - days MPa | Splitting Tensile resistance 28-days MPa | Flexural Strength 28-days MPa |
|----------|-----------------------------|-----------------------------|-----------------------------|----------------------------------------|-----------------------------|
| HF0      | 1750                        | 16.34                       | 20.85                       | 1.8                                    | 3.12                        |
| HF1      | 1810                        | 17.56                       | 24.35                       | 2.94                                   | 5.87                        |
| HF2      | 1830                        | 18.25                       | 25.15                       | 4.22                                   | 6.53                        |
| HF3      | 1840                        | 15.55                       | 22.35                       | 5.34                                   | 7.24                        |
| HF4      | 1755                        | 16.34                       | 22.56                       | 1.94                                   | 3.53                        |
| HF5      | 1760                        | 16.25                       | 21.25                       | 2.23                                   | 4.25                        |
| HF6      | 1764                        | 15.62                       | 18.35                       | 1.98                                   | 4.75                        |
| HF7      | 1812                        | 17.56                       | 18.32                       | 2.95                                   | 5.94                        |
| HF8      | 1846                        | 18.35                       | 27.85                       | 3.67                                   | 6.55                        |
| HF9      | 1833                        | 17.54                       | 19.34                       | 6.47                                   | 8.35                        |
| HF10     | 1832                        | 16.34                       | 18.43                       | 3.37                                   | 7.32                        |

Figure 8. Strength of compressive test (SLWSCC) results at 7-days and 28-days.
5.2.3 Splitting tensile strength.

Results of the strength of splitting tensile (SLWSCC) mixes were summarized in Table (5). It’s indicate that the steel fiber exceedingly increases the splitting tensile strength of (SLWSCC), for example at (HF1, HF2, and HF3) mixtures for 0.3%, 0.6%, and 1.2% by fraction of volume steel fiber has about 63.3%, 134, and 197% increases in the splitting tensile strength comparison with the (HF0) control mix, such as graphically presented in Figure (10), and apparent at the graph, R² value the (0.95) presents the exceedingly well relation among the content of fiber and concrete strength of splitting tensile, and which due to fibers is bridging the macrocracks and block the crack improvement. Whereas the stress of tensile is transported to fibers, the transporter is able to imprison the improvement of microcracks and to make better the concrete splitting tensile strength [30]. Figure (12): shows the failure mode of strength of splitting tensile for (SLWSCC) with steel fibers of (28)-days.

Also in the Figure (10), the addition of PP fibers may raise the tensile resistance of (SLWSCC) but not the same manner of steel fibers. The high increasing of strength of tensile at the (HF5) mixture of 0.6% PP fibers volume fraction was 23.89% comparing to (RF0) reference mix and comparison with (HF3) of 1.2% steel fibers was 43.2%.

The differences at strength of splitting tensile with hybrid fibers were introduced at Figure (11), resultants indicate that hybrid fibers are increasing the strength of tensile, with 0.3% steel fibers and 0.3% PP fibers volume fractions at (HF7) mix raises the strength of splitting tensile by around 52.1% and 0.34% more the strength of splitting tensile for the (HF1) and (HF4) mixes. For (HF8) hybrid fibers mix of 0.6% steel fibers and 0.3% PP fibers volume fractions reducing the splitting tensile strength about 15% compared with (HF2) mix. The optimum splitting tensile strength was 7.47 MPa at (HF8) mix of 0.6% of steel fibers and 0.3% of PP fibers, the improvement of splitting tensile strength go down to 4.37 MPa when increasing the hybrid fibers content to 0.6% of PP fibers and 1.2% (SF) in (HF10) mixes.

Figure 9. Dry density test resultants of (SLWSCC) at and 28-days.

Figure 10. Strength of compressive test (SLWSCC) results at 28-days.
5.2.4 Flexural strength.

Resultants display an increasing in concrete strength of flexural through the raise at fiber type and volume fractions, as can be seen at Table (5), and graphically represented in Fig.13. Increase in volume percentage of steel fibers from 0.3% to 1.2% the module of rupture change shows an ascending trend are increased by 88.1% and 132% respectively with respect to the reference mixture (HF0) at 28 days that is due to the fibers begin to make a bridge the cracks and this growing the extreme load [25].

Moreover, the addition of PP fiber volume fractions from 0.3% to 1.2% by increment 0.3% for (HF4), (HF5) and (HF6) of (SLWSCC) causes the flexural strengths increase 13.1%, 36.2%, and 52.2% respectively with respect to the plain at the age of 28 days and not to the similar of steel fibers, because of the lower strength of tensile of (P.P.F) and the not strong bonding between cement matrix and (P.P.F)[26].

The comparison between modulus of rupture values of (HF7- SLWSCC) samples of 0.3% hybrid fibers with (HF1), and (HF4) of 0.3% of unique fibers shows that the increase the strength of flexural for hybrid fiber (SLWSCC) samples are 1.2%, and 68.27% respectively. That may be because mixes of concrete with dissimilar fibers types is well be able to connect the principal crack therefore, the micro-mechanical appearance of crack bridging acts from the stage of damage evolution to ultimate loading. Also with increasing the hybrid fibers content increasing the modulus of rupture as for (HF8), (HF9) and (HF10) mixes were 6.55MPa, 8.35MPa, and 9.32MPa respectively. Figure (12) shown the failure mode of flexural strength for (SLWSCC) at 28-days. The significant discovery of the test strength of flexural was that the mix of concrete at 0.6% content of steel fiber and 0.3% PP fibers exhibits higher flexural strength behavior by 6.45MPa.

Figure 11. Strength of splitting tensile for overall (SLWSCC) mixtures of (28)-days.

Figure 12. Failure mode of flexural and splitting tensile strength of (SLWSCC) mixtures at (28)-days.
6. Conclusion
The results of this experimental study on the (SLWSCC) reinforced with various volume fractions of hybrid fibers support the following conclusions:
1. Slump flow and L-box passing ability to become smaller, and V-funnel time rose within the addition in the content fiber volume and reducing the followability of the (SLWSCC). In many directions, the slump of the mixture was somewhat reduced as well as PP fibers, as compared to steel fibers, had lower influence in fresh mixture workability.
2. Steel fibers appreciably influence both compressive and flexural properties. However, the influence on flexural quality is rather than from these at compression conduct. Steel fibers significantly increase the flexural resistance (up to about 132%). At the same time that, they have limited influence at increasing the compression strength (up to about 11%). The splitting tensile strength of (SLWSCC) improves significantly by incorporating 1.2% steel fibers (vol. %). The splitting tensile evaluated around (114%) more than the strength of splitting tensile of the reference of (SLWSCC).
3. Polypropylene fibers have influence for mechanical properties of concrete at 0.3% volume ratios and more. The addition of 0.6% PP fibers at concrete mixtures has an influence on compressive characteristics. The improving of PP fibers is more can be recognized in the mixtures that do not include any steel fibers. Therefore, the lower magnitude of polypropylene fibers to be used in lightweight concrete to preclude brittle behavior is toward 0.6% with volume of concrete.
4. The hybrid fibers influence in (SLWSCC) reduces the danger of the aggregates segregation, and improves the mixture uniformity, also increases the bulk density of (SLWSCC) specimens with in addition to 1.2% steel fibers increases the concrete density by means of around 1833 kg/m3.
5. Hybrid fibers improved the mechanical properties of (SLWSCC) whatever; the value of compressive strength development because of the including of hybrid fibers is lower than that in flexural and tensile strengths. The highest strength of tensile was registered from 1.8 MPa in reference mixture to 6.67 MPa in the (HF8) mixture of 0.6% steel fiber and 0.3% PP fibers. The strength of flexural was increasing from 3.12MPa at reference mixture to 9.55 MPa at the hybrid fiber reinforcing mixture (HF8). In this way, the maximum improvement in tensile strength is 129% while the higher improvement at strength of flexural is 206%.

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