A Comparative Study between the Effect of Steel Fiber on Ultrasonic Pulse Velocity (UPV) in Light and Normal Weight Self-Compacting Concretes

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Abstract : This research presents a comparative study to highlight the differences between the effect of using various contents of steel fibers on the ultrasonic pulse velocity (UPV) in two types of self-compacting concretes (SCC) which are identical in their constituent materials, the only difference between them is the coarse aggregate type (normal in one and light in the other) with various specimen lengths (200mm cylinders and 100mm cubes). In this work, six types of mixes were casted, the first three (Mix1, Mix2 and Mix3) are of normal-weight SCC having steel fiber content (Vf) : 0.0%, 0.4% and 0.8% respectively, and the other three (Mix4, Mix5 and Mix6) are of light-weight SCC with the same aforementioned steel fiber contents respectively. It turns out that, the ultrasonic pulse velocity is smaller in light-weight SCC than in normal-weight SCC, and the percentage of this reduction is higher in cylindrical samples than in cubic samples, and this percentage of reduction is reduced with the increasing in steel fiber contents. It also turns out that, the ultrasonic pulse velocity is increased with the increase in steel fiber contents, and this percentage of increase is higher in light-weight SCC than in normal-weight SCC, and it is also larger in cylindrical samples than in cubic samples. Moreover, when the specimen length has been focused on, it was found that, the ultrasonic pulse velocity is larger in (100mm) cubic specimens than in (100×200mm) cylindrical ones, and the percentage of this rise is also larger in light-weight SCC than in normal-weight SCC, and it is reduced with increasing steel fibers contents.
1. Introduction

Self-compacting concrete (SCC) is one of concrete types having a good flowing capability by its self-weight and attain an adequate compaction without external vibrating. Furthermore, because of its consistency features, self-compacting concrete has a quite good resistance to bleeding and segregation [1].

Self-compacting concrete is recognized to be brittle and can crack easily under small tensile forces. Naturally, plain concrete is a brittle material, having a limited strain capacity and a small tensile strength. This brittleness behaviour can be overcome by the usage of small separated randomly oriented steel fibers. The added fibers, not only suppress the initiation of cracks, but also recede their growth and spread [2].

Fibrous concretes become a considerable selection whenever safety or toughness consideration is a design criteria. Fibrous concretes improve the performance (i.e. strength and durability) and efficiency of brittle cement-based material by bridging the crack, restraining the spread of cracks and transmitting stress across cracks [3].

Numerous researches and investigation efforts had been carried out for improving the self-compact concrete by adding steel fibers to it [4, 5, 6, 7, 8, 9].

The non-destructive tests (like ultrasonic pulse velocity one) have been vastly used for the determination of concrete characteristics without exposing concrete structures to destruction [10, 11, 12, 13, 14, 15, 16].

Several researchers have investigated the effectiveness of using (UPV) test in evaluating the concrete quality several years ago. This sort of measurement has proved to be of genuine interest as a useful accomplishment for the assessment of the properties and quality of the concrete structure. The most desirable aspect of this test is that the concrete remains safe during the test, in addition to the quickness and simplicity in using it, besides the availability of the testing results at site and the less expensive equipment that can be used for this objective [17, 18, 19, 20, 21].

Pulse velocities are affected, however, by several parameters, including: (W/C) ratio [22, 23], mixture proportion, aggregate type, concrete age, moisture content [24].

2. Research Significance.

This research presents a comparative study to draw attention to the differences between the effect of using various contents of steel fibers on the ultrasonic pulse velocity (UPV) in two types of self-compacting concretes which are identical in their constituent materials, the only difference between them is the coarse aggregate type (normal in one and light in the other) with various specimen lengths (200mm cylinders and 100mm cubes).

3. Experimental Work

3.1 Materials

3.1.1 Cement

Ordinary Portland cement from "Tasluja" local factory was used for all mixes in the current study.

3.1.2 Normal-Weight Fine Aggregate (Sand)

The fine aggregate (sand) used in the current study was taken from "El-Ukhaidhir" territory field. The specific gravity and maximum size of sand particles are (2.6) and (4.75) mm respectively. The physical test made for this fine aggregate was executed. The results reveal that the grading of the sand satisfies the acceptable range of the Iraqi Specifications No. 45 / 1984 [25]. Before using the sand it was exposed to direct sunlight until full dryness is reached.

3.1.3 Normal-Weight Coarse Aggregate

Natural (locally existed) normal-weight gravel (of rounded shape particles) with (10mm) maximum size and (2.63) specific gravity was used as coarse normal-weight aggregate in this work. It was obtained from "AL-Nibaai" zone field. The physical test of coarse aggregate was also executed, and the results turned out that the grading of the gravel was satisfies the acceptable range specified by
ASTM C33 [26]. It has also been found that the sulphate content satisfies the acceptable range of the Iraqi Specifications No.45 / 1984 [25].

3.1.4 Light-Weight Coarse Aggregate

Natural (locally existed) light-weight aggregate of Porcelinite stones imparted from Trifawi (Rotba) region in El-Enbar territory was used as coarse light-weight aggregates in the current study. It is transported and tested in the State Company of Geological Survey and Mining (SCGSM) laboratories. Firstly, the light-weight aggregate masses are smashed by hand into small sizes by special knockers to facilitate its insertion into the orifice of the Jaws smashing machine.

Table (1) present the physical properties obtained from the analysis executed for “Porcelinite” coarse light-weight aggregate. Three sizes of “Porcelinite” aggregate which satisfied the acceptable limits of ASTM C-330 [27], are mixed to attain the light-weight coarse aggregates in the current research, and they are demonstrated in Table (2).

### Table (1): Physical Characteristics of Porcelinite Coarse Aggregate.

| Property                  | Specifications   | Test Results |
|---------------------------|------------------|--------------|
| Percentage of Absorption  | ASTM C-127 [28]  | 33.9         |
| Dry rodded Density (Kg/m³)| ASTM C-29 [29]   | 680          |
| Dry loose Density (Kg/m³)| ASTM C-29 [29]   | 635          |
| Specific Gravity          | ASTM C-127 [28]  | 1.53         |

### Table (2): Grading of Coarse Porcelinite Aggregate.

| Cumulative (% passing [ASTM C-330]) | Size of Light-Weight aggregate (Porcelinite) (mm) | Size of sieve (mm) | Percentage Using (%) | Accumulative Percentage passing |
|--------------------------------------|-------------------------------------------------|-------------------|----------------------|-------------------------------|
| 100                                  | 9.5 < S < 12.5                                   | 12.5              | 15                   | 100                           |
| 80 - 100                             | 4.75 < S < 9.5                                   | 9.5               | 55                   | 85                            |
| 5 - 40                               | S < 4.75                                        | 4.75              | 30                   | 30                            |

3.1.5 Admixtures (Super-plasticizer)

In this work, a suitable super-plasticizer called “SikaVisco Cete-PC 20” was used with a dose of 3.5 litres per 100 kilograms of cement, and the selected dosage was settled on after several trial mixtures. This mixture improves the workability (i.e. flow-ability) of the mix as:

- Considerably strong water-reduction, leading to high strength and density, and low permeability for water.
- Very good plasticizing influence, leading to improve flow-ability, casting and compacting behaviour.
- Specially appropriate for producing SCC.

Table (3) illustrate the properties of the super-plasticizer used in the current work.

### Table (3): Characteristics of the Super-plasticizer*

| No. | Designation  | Descriptions                                      |
|-----|--------------|---------------------------------------------------|
| 1   | Trade name   | SikaVisco Cete-PC 20                             |
| 2   | Form         | liquid                                            |
| 3   | Color        | Light brown                                       |
| 4   | Chemical Base| Modified poly-carboxylates based polymer           |
| 5   | Density      | (1.09 - 1.13) kilograms/litre @ 20°C              |
| 6   | Chlorides    | Free from chlorides                               |
| 7   | PH           | 3 - 7                                             |

*As given by the source.
3.1.6 Steel Fiber

Steel fibers with hooked ends (of a commercially name : "Dramix-Type ZC") are utilized in the current work. Steel fibers are of (0.5mm) diameter and (50mm) long (i.e. they have an aspect ratio : D/L = 0.01). The features of the steel fiber used are displayed in Table (4).

**Table (4) : Steel fibers properties**

| Configuration      | Trade Name | Properties          | Specification |
|--------------------|------------|---------------------|---------------|
| Hooked ends        | Dramix-ZC-50/0.5 | Tensile-strength | 1130 MPa |
|                    |            | Unit weight         | 7860 kg/m³   |
|                    |            | Poisson's ratio     | 0.28          |
|                    |            | Elastic modulus     | 200 \( \times \) 10³ MPa |
|                    |            | Strain at yield point | 5650 \( \times \) 10⁶ |
|                    |            | Nominal diameter    | 0.5 mm        |
|                    |            | Length              | 50 mm         |
|                    |            | \((L_f / D_f)\)     | 100           |

*As supplied by the manufacturer.

3.1.7 Lime Stone Powder (LSP)

(LSP) is a filler named locally as: “El-Ghobra”. It is a white lime-stone grinded material extracted from various fields in Iraq, and often utilized in numerous constructional works.

3.2 Concrete Mixes.

In this work, six types of mixes were casted, the first three (Mix1, Mix2, and Mix3) are of normal-weight SCC having SF content : 0.0% , 0.4% , and 0.8% respectively, and the second three (Mix4, Mix5, Mix6) are of light-weight SCC with the same aforementioned SF contents respectively, as illustrated in figure (1).

In order to produce a non-fibrous normal-weight SCC, the following weighted mixing proportions were used : \([1 : 0.05 : 1.95 : 2]\) for cement, lime-stone powder, sand and gravel respectively, the \((w/c)\) ratio used was (0.44) and the super-plasticizer content was (3.5) litre for each (100) kg of cement. These mix proportions were decided after different trial mixes made until the most satisfactory one is reached. The aforementioned mix proportions was found to produce a self-compact concrete without segregation. These proportions tend to pursue the British practice which has generally trends to use higher content of sand (approximately equal to gravel content) with (10mm) maximum size to assure the best dispersion of steel fiber (later on) in the mix [30].

Steel fibrous reinforced SCC was made by sprinkling steel fiber with the required content \((V_f : 0.4\% \text{ or } 0.8\%)\) to the fresh plain concrete, then the mixture is well remixed. The uniform dispersal of the steel fiber and the workability of the mix are the two important parameters that the quality of fibrous concrete is depend upon.

For the light-weight SCC, the following weighted mixing proportions were used for non-fibrous concrete : \([1 : 0.05 : 1.95 : 0.95]\) for cement, limes-tone powder, sand and light-weight coarse aggregate “Porcelinite” respectively. The \((w/c)\) ratio and the super-plasticizer content used for light-weight SCC was also (0.44) and (3.5 liter per 100 kg of cement) respectively. These mixing proportions have also followed the British practice which has a tendency to use high content of sand with maximum size of (10mm) to assure the best dispersal of steel fibers [30]. Fibrous reinforced SCC was produced by the same aforementioned manner for normal weight SCC.
3.3 Mixing Operation

Mixing process has a considerable role for producing self-compacting concrete which satisfies criteria of filling and passing abilities as well as segregation resistance. The better spread of fibers prohibits fibers agglomeration. All SCC batches was made by weight and mixed manually by using a bowl. Before pouring the constituent materials in the bowl, the interior surface of it must be clean and moistened. To distribute the steel fiber uniformly and prevent its agglomeration, the assigned quantity of steel fiber was manually and uniformly scattered to the mix. Then, fresh concrete mix was re-mixed to attain a uniform spread of the fibers. The process (for light-weight and normal-weight SCCs) is demonstrated in the points below:

1. First of all, fine, coarse aggregates and the filler, were poured into the bowl and mixed for several minutes, thereafter, the cement was then poured to the mix and all combinations were re-mixed to obtain a homogeneous mixture.
2. Since \((W/C)\) ratio = 0.44, so that, the water amount \(W = 0.44C\). For the purpose of having an effective mixing procedure, this total amount was divided into four portions: \(W_1 = 0.2C, W_2 = 0.08C, W_3 = 0.12C, W_4 = 0.04C\).
3. The amount of \((W_1)\) was first poured on the mixture and all components were re-mixed for several minutes.
4. Then, the amount of the super-plasticizer was added to the amount of \((W_2)\), re-mixed and left for a few minutes.
5. After that, the amount of \((W_3)\) was poured and remixed to have a homogeneous fresh concrete mix.
6. At last, the remaining amount of \((W_4)\) was poured and all components were mixed to prepare for casting.
7. For mixtures containing steel fibers, for the purpose of uniformly distributing steel fibers and preventing its agglomeration, the assigned quantity of steel fiber was well scattered to the mixture manually. Fresh concrete was then well re-mixed to attain a uniform dispersal of the fibers.

3.4 Casting and Curing of Specimens.

As soon as mixing operation was completed, the fresh concrete was then poured into the moulds displayed in Fig. (2), and then vibrated by knocking at the base and sides of the moulds till the end of casting. To prohibit water evaporation, the samples were covered with a sheet of nylon. About 24 hours later, the specimens were put in a water bath for curing. Two heaters were used to keep the temperature of the bath at about 25\(^{\circ}\)C to 30\(^{\circ}\)C. To distributed the heat all over the bath water, a water pump was also used. After about thirty days, the specimens were removed from the water basin to be prepared for testing.
3.5 Testing of Self-Compacting Concrete.

The experimental work of the current study was carried out in the laboratory of structural materials in the Faculty of Engineering at Mustansiriya University, the aforementioned laboratory is an integrated laboratory that contains many testing machines, and the experimental work of many of our researches such as [31-38] was carried out in that laboratory. The following two sections demonstrate the results of the standard tests that were performed for the fresh and hardened self-compacting concretes SCC.

3.5.1 Tests of Fresh SCC.

3.5.1.1 Slump Flow and T-50 Tests

Slump-flow test is the most commonly used test to estimate the horizontal free flow of self-compacting concrete SCC which gives a good evaluation of its flow-ability. It can also give an indicator of segregation resistance. T-50 test is also a good indicator of the flow speed, and consequently, the viscosity of SCC [39]. T-50 test was primarily designed to measure the viscosity of under-water concretes and was also used to assess the highly flow-able concrete [40].

Slump flow test is mainly established to estimate the flow-ability of SCC, and can signalize the resistance to segregation of SCC by a professional user [40]. The outcomes of slump flow test are illustrated in table (5). Values of (D) column represent the final diameter of the slump flow (the maximum spread), whereas the values of (T-50) column refer to the required time for the flow of concrete to reach a (50cm) diameter circle, as seen in Figure (3). Table (5) also illustrates that the results satisfy the acceptance-criteria for SCC [41], and illustrates that the flow-ability was decreased when steel fibers were added to the SCC.

| Types of SCC | $V_f$ (%) | T-50 (Sec.) | D (mm) | Acceptance - Criteria for SCC |
|--------------|----------|-------------|--------|------------------------------|
| Normal weight |          |             |        |                              |
| 0            | 6        | 630         |        |                              |
| 0.4          | 7        | 620         |        |                              |
| 0.8          | 9        | 610         |        |                              |
| Light weight |          |             |        |                              |
| 0            | 4        | 645         |        |                              |
| 0.4          | 5        | 625         |        |                              |
| 0.8          | 6        | 620         |        |                              |

Table (5) : Slump-Flow Test Results and Acceptance-Criteria for SCC.
3.5.2 Tests of Hardened SCC.

3.5.2.1 Ultrasonic Pulse Velocity Test

Ultrasonic pulse velocity (UPV) measure test boils down to send a pulse wave through concrete and measure the time travelled for the wave to transmit through the concrete, and since the travel distance is known, the velocity of the wave pulse will be easily found. This velocity has a considerable indication to the strength of the tested concrete. In this test, an ultrasonic pulse wave is generated by a pulse generator and transmitted to the surface of concrete through the transmitter transducer. The time travelled by the pulse through the concrete is measured by the receiver transducer on the opposite side. The contact surface between concrete and the transducer is greased, so as to ensure efficient transfer of the pulse wave.

The ultra-sonic pulse velocity test was achieved according to ASTM C597–02 [42], using L = 200mm (for cylinders), or L = 100mm (for cubes), as seen in figure (4).

The velocity of the pulse is given by the following equation (1) :-

\[ V = \frac{L}{T} \times 10^3 \]  . . . . . . . . . . . . (1)

Where:-

\( V \) = Velocity of the pulse, (m/s).
\( L \) = Distance between the center of transmitter and receiver transducers’ faces, (mm).
\( T \) = Transducer time travelled, (\( \mu \)s).

![Fig (3) : Slump-Flow Test](image-url)

![Fig (4) : Ultrasonic Pulse Velocity (UPV) Measuring Details for Cubic and Cylindrical Specimens.](image-url)
4. Results and Discussions.

4.1 Effect of Concrete Type on UPV with Various Steel Fiber Contents in Cubic and Cylindrical Specimens.

When a comparative study is executed between two types of SCCs which are identical in their constituent materials, the only difference between them is the course aggregate type (normal in one and light in the other), table (6) and figures (5) and (6) illustrate that UPV in light-weight SCC is smaller than in normal-weight SCC, and this behavior is applicable for all steel fiber contents and for both cubic and cylindrical specimens. The reason for this behavior might be because the small density of light-weight aggregate (in light-weight SCC) as well as the porous nature of light-weight SCC reduce the ability for transmitting the ultrasonic pulse wave and hence reduce the UPV.

It can also be noticed from the aforementioned table and figure that the percentage of this reduction in UPV (between the two values related to the two concrete types) is decreased with the increase in SF contents. The explanation for this attitude might be because the effect of SF in increasing UPV is more efficient for light-weight SCC than for normal-weight because of its ability to minimize the bad effect of the voids and the light-weight aggregate on UPV.

On the other hand, this percentage of reduction in UPV is noticed to be higher in cylindrical specimens than in cubic specimens. This behavior might be imputed to the fact that when ultrasonic pulse wave passes through a smaller path (100 mm cubic specimen), the possible number of internal voids, cracks and porous light-weight aggregate that are slowing down the ultrasonic wave will be smaller than for longer (200 mm cylindrical specimen), these hindrances are increased in light-weight SCC than in normal-weight, therefore their effect on UPV will be lesser (and consequently, UPV will be higher) in cubic specimens than in cylindrical ones.

Table (6) : Effect of SCC Type on UPV with Various Steel Fiber contents in Cubic and Cylindrical Specimens.

| Length of specimen | Vf (%) | SCC Type        | Ultrasonic Pulse Velocity UPV (m/s) | Percentages of Decrease (%) |
|--------------------|--------|----------------|------------------------------------|----------------------------|
| 100 mm cube        | 0.0    | Normal - weight| 4334                               | ----                       |
|                    |        | Light - weight | 3588                               | 17.2                       |
|                    | 0.4    | Normal - weight| 4355                               | ----                       |
|                    |        | Light - weight | 3620                               | 16.9                       |
|                    | 0.8    | Normal - weight| 4364                               | ----                       |
|                    |        | Light - weight | 3661                               | 16.1                       |
| 200 mm cylinder    | 0.0    | Normal - weight| 4133                               | ----                       |
|                    |        | Light - weight | 3053                               | 26.1                       |
|                    | 0.4    | Normal - weight| 4187                               | ----                       |
|                    |        | Light - weight | 3127                               | 25.3                       |
|                    | 0.8    | Normal - weight| 4271                               | ----                       |
|                    |        | Light - weight | 3231                               | 24.4                       |
Effect of Steel Fiber Content on UPV with Various Specimen Lengths in Normal and Light-Weight SCC.

Table (7) and figures (7) and (8) show that UPV is increased with the increase in SF contents, and this behavior is applicable for both concrete types (normal and light-weight SCCs) and for cubic and cylindrical samples. The reason for this behavior may be because the UP wave is faster in metallic than in non-metallic materials and it is undoubtedly that, as the steel fiber content increases, the conductive nature of the specimen approaches minerals (metals), thus the UPV increases.
The aforementioned table and figure also reveal that the percentage of this increase in UPV is higher in light-weight SCC than in normal-weight SCC, and the reason for this behavior might be because the small density of light-weight aggregate (in light-weight SCC) as well as the porous nature of light-weight SCC reduce the ability for transmitting the ultrasonic wave, and hence, the effect of SF in increasing UPV is more efficient for light-weight SCC than for normal-weight because of its ability to minimize the bad effect of the voids and the light-weight aggregate on UPV.

Furthermore, when SF is added, the percentage of increase in UPV is noticed to be higher in cylindrical samples than in cubic samples. This behavior may be demonstrated by the fact that when ultrasonic pulse wave passes through a longer path (200 mm cylindrical specimen), the expected number of internal voids, cracks and porous light-weight aggregate that are slowing down the ultrasonic wave will be larger than for smaller (100 mm cubic specimen), and hence, the ability of SF in reducing the bad effect of these hindrances is more efficient in cylindrical samples than in cubic samples.

**Table (7) : Effect of Steel Fiber Contents on UPV with Various Specimen Lengths in Normal and Light-Weight SCC.**

| Length of specimen | Vf (%) | Ultrasonic Pulse Velocity UPV (m/s) in Normal-Weight SCC | Percentage of Increase (%) | Ultrasonic Pulse Velocity UPV (m/s) in Light-Weight SCC | Percentage of Increase (%) |
|--------------------|--------|----------------------------------------------------------|---------------------------|---------------------------------------------------------|---------------------------|
| 100 mm cubes       | 0.0    | 4334                                                     | ----                      | 3588                                                    | ----                      |
|                    | 0.4    | 4355                                                     | 0.5                       | 3620                                                    | 0.9                       |
|                    | 0.8    | 4364                                                     | 0.7                       | 3661                                                    | 2.0                       |
| 200 mm cylinders   | 0.0    | 4133                                                     | ----                      | 3053                                                    | ----                      |
|                    | 0.4    | 4187                                                     | 1.3                       | 3127                                                    | 2.4                       |
|                    | 0.8    | 4271                                                     | 3.4                       | 3231                                                    | 5.8                       |

*Percentage of increasing*

**Fig. (7) : Effect of Steel Fiber Content on UPV with Various Specimen Lengths in Normal-Weight Concretes.**
4.3 Effect of Specimen Lengths on UPV with Various Steel Fiber Contents in Normal and Light-Weight SCCs.

From table (8) and figures (9), (10) and (11), one can notice that the UPV in cubic specimens are higher than in cylindrical specimens, and this behavior is applicable for all SF contents and for both concrete types (normal and light-weight SCCs). The reason behind this result may be because when ultrasonic pulse wave passes through a smaller path (100 mm cubic specimen), the expected number of internal voids, cracks and porous light-weight aggregate that are slowing down the ultrasonic wave will be smaller than for longer (200 mm cylindrical specimen).

One can also notice (from the aforementioned table and figure) that the percentage of this increase in UPV is reduced with increasing steel fiber contents, and this behavior is applicable for both concrete types (normal and light-weight SCC). This attitude might be interpreted through the ability of steel fiber in reducing the bad effect of internal voids, cracks and porous light-weight aggregate that are slowing down the ultrasonic wave is more efficient in cylindrical samples than in cubic samples.

Moreover, it has noticed that this percentage of increase in UPV is higher in light-SCC than in normal SCC, and the explanation for this behavior might be because the influence of the sample length on UPV is larger in light-weight SCC than in normal-weight because of the porosity of its aggregate.

**Fig(8) :** Effect of Steel Fiber Contents on UPV with Various Specimen Lengths in Light-Weight Concrete.
Table (8) : Effect of Specimen Lengths on UPV with Various Steel Fiber contents in Normal and Light-Weight SCCs.

| Vf (%) | Specimen Length | Ultrasonic Pulse Velocity UPV (m/s) in Normal weight SCC | Percentage of Increase (%) | Ultrasonic Pulse Velocity UPV (m/s) in Light weight SCC | Percentage of Increase (%) |
|--------|------------------|----------------------------------------------------------|-----------------------------|----------------------------------------------------------|----------------------------|
| 0.0    | 200 mm cylinders  | 4133 ----------                                          | 3053                        | 4.9                                                      | 17.5                       |
|        | 100 mm cubes     | 4334 4.9                                              | 3588                        |                                                          |                            |
| 0.4    | 200 mm cylinders  | 4187 ----------                                          | 3127                        | 4.0                                                      | 15.8                       |
|        | 100 mm cubes     | 4355 4.0                                              | 3620                        |                                                          |                            |
| 0.8    | 200 mm cylinders  | 4271 ----------                                          | 3231                        | 2.2                                                      | 13.3                       |
|        | 100 mm cubes     | 4364 2.2                                              | 3661                        |                                                          |                            |

*Percentage of increasing

Fig. (9) : Effect of Specimen Lengths on UPV with Steel Fiber Content = (0.0%) in Normal and Light-Weight Concretes.
5. Conclusion.

1) When a comparative study have carried out between two types of SCCs which are identical in their constituent materials, the only difference between them is the coarse aggregate type (normal in one and light in the other), it turns out that, the ultrasonic pulse velocity is smaller in light-weight SCC than in normal-weight one, and the percentage of this decrease is higher in cylindrical samples than in cubic samples, and it is reduced with the increase in steel fiber contents.

2) When steel fiber is added with contents (0.0%, 0.4% and 0.8%), it turns out that, the ultrasonic pulse velocity is increased with increasing steel fiber contents, and this percentage of increase is higher in light-weight SCC than in normal-weight one, and it is also higher in cylindrical samples than in cubic samples.

Fig. (10) : Effect of Specimen Lengths on UPV with Steel Fiber Content = (0.4%) in Normal and Light-Weight Concretes.

Fig. (11) : Effect of Specimen Lengths on UPV with Steel Fiber Content = (0.8%) in Normal and Light-Weight Concretes.
When the specimen length has been focused on, it was found that: The ultrasonic pulse velocity is higher in cubic specimens than in cylindrical ones, and the percentage of this rise is also higher in light-weight SCC than in normal-weight one, and it is reduced with increasing steel fiber contents.

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