International Journal of Civil Engineering and Technology (IJCIET)
Volume 9, Issue 12, December 2018, pp. 993–1005, Article ID: IJCIET_09_12_102
Available online at http://www.iaeme.com/ijciet/issues.asp?JType=IJCIET&VType=9&IType=12
ISSN Print: 0976-6308 and ISSN Online: 0976-6316

THE EFFECT OF FIBERS ON THE PROPERTIES OF SELF-COMPACTING CONCRETE SUBJECTED TO PETROLEUM PRODUCTS

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ABSTRACT

The substantial target of this study is to examine the influence of oil products on self-compacting concrete reinforced by adding various kinds of fibers. In this work different concrete mixes were implemented with incorporation of several kinds of fibers (FRSCC) such as (polypropylene fibers, micro steel fibers, and hybrid steel fibers plus polypropylene fibers). The results were compared (with a control mix). Workability and compatibility at the fresh state tests were within the acceptable criteria, and after hardening by means of mechanical properties, in addition to the total absorption after exposure to the petroleum products as compared with the same kinds of mixes which were exposed to water at same exposure periods (30, 60, 90, and 180) days.

It was noticed that all the tested mechanical properties of prepared mixes that were continuously exposed to oil products after 30 days were adversely affected, while the results of specimens continuously immersed in water were promoted the mechanical properties of concrete. Moreover, the results of total absorption give an increase in all mixes continuously immersed in oil products. Finally, the results revealed an increasing in all mechanical properties as a resulting of adding of fibers (FRSCC) after exposure to gas oil and kerosene relative to reference mixture (SCC) that was cured in the same condition.

Key words: Self-Compacting Concrete, Fibers Reinforced Self-Compacting Concrete, Oil Products, Exposure Periods.

Cite this Article: Ahmed Abed Alsajjad Salman, Jinan Jawad Hassan Alwash and Najm O.S. Alghazali, The Effect of Fibers On The Properties of Self-Compacting Concrete Subjected To Petroleum Products, *International Journal of Civil Engineering and Technology (IJCIET)* 9(12), 2018, pp. 993–1005.
http://www.iaeme.com/ijciet/issues.asp?JType=IJCIET&VType=9&IType=12

1. INTRODUCTION

Oil has become one of the ultimate indispensable energy resources from the beginning of the proceeding century for being the only one of their kinds for economic and operative characteristics. This has made it surpass the other obtainable power resources, and its significance has enhanced quickly with its wide use and the invention of massive oil in a different parts of the world.

There is a diversity in behavior of the water storage concrete tanks and petroleum storage concrete tanks, demonstrated by the fact that escape and leakage of fluid through the cracks in water storage concrete tanks may be minimized with time because of the closure of some of gaps, separation of the capillary path and healing of several of the cracks and consequent of continuous hydration, because of the inert nature of the petroleum to concrete, such continued hydration is less likely to happen in petroleum concrete tanks, but the deposits of wax that are found in crude oil may diminish the concrete permeability ***(Matti, 1976)***. Thus, it is of significant to relief the cracks to a lower limit to abolish any seepage of oil from the construction and to maintain the concrete from damage. Therefore, so it is necessary to use SCC which it has have a relatively low yield value, a reasonable viscosity to withstand bleeding and segregation, and has have to persist its homogeneity and long period of time for durability ***(European Project Group, 2005)***,and including specific proportion of pozzolanic materials such as silica fume and reinforced by fibers so that it can be deemed as one method to virtually minimize the permeability of concrete through diminishing pore size, improving the mechanical properties, durability, and minimizing final absorption for concrete ***(Sabet et. al., 2013 and Mastali and Dalvand, 2016)***.

This improvement are resulted from the capability of fibers to modify the failure mechanisms of composite materials by limiting the macrocracks and microcracks mode. Fibers provides the better strength and stiffness for the brittle cement-based materials by bridging cracks, and transfer stress from one crack tips to another ***(Qian et. al., 2000)***. The efficiency of concrete store reservoir requires domination on impermeability and cracking. Commonly, concrete suffer from the property of depressed tensile strength and propensity to cracks under tensile stresses generated by external loads, creep, thermal gradients, and shrinkage. Generally the long term loading provides through the percentage of fibers in concrete***(Abdul-Ahad et. al., 2000)***.

The study of theeffect of adding steel fibers on mechanical properties of concrete after exposure to petroleum products has beendone by***(Abed Al-Ameer, 2011)***,while ***(Al-Weli, 2016)***examines the impact of petroleum products on engineering properties of polymer modified for self-compacting concrete (PMSCC).

2. EXPERIMENTAL WORK

2.1. Materials

2.1.1. Cement

In this investigation a Portland limestone cement (PLC) was used which it is manufactured by Lafarge company.

2.1.2.Fine Aggregate

In this work natural sand from Al-Ukhaider zone was utilized. Fine aggregate grain have specific gravity of (2.65) and maximum size of (4.75mm). The chemical and physical properties made for this fine aggregate were executed by constructional materials laboratory in the University of Babylon. The obtained results were within acceptable limits of ***Iraqi specification No. 45/1984***.

2.1.3. Coarse Aggregate

Rounded gravel with nominal size 14 mm from Al-Niba'ee quarry was used as a coarse aggregate in whole mixes, with specific gravity (2.65). The grading and physical properties of coarse aggregate are within limits of ***Iraqi specification No. 45/1984***. The test has been done by constructional materials laboratory in the university of Babylon.

2.1.4.Lime Stone Powder (LP)

This material is available locally called "Al-Gubra". It is a white mashing material from lime-stones elicited from various zones in Iraq , used for the increment of powder. The obtained results from chemical analysis comprises $CaCO_3$ by 85%, CaO by 45%, and L.O.I were about 40%.

2.1.5. High Range Water Reducing Admixture

Superplasticizer is used during this research (formally recognized as Flocrete PC200). This influence enable it to apply in high strength and flowability for the concrete mixtures, to attain concrete with high durability and efficiency. The guidance dosage of Hyperplast PC200 is 0.5- 2.5litre / 100kg of materials of cementitious in the mixture. The technical properties are shown in Table 1.

Table (1) Technical properties of PC 200 @ 25 C^o

Form	Color	Freezing point	Specific gravity	Air entrainment
Viscous liquid	Light yellow liquid	~-3C^o	1.05±0.02	Typically less than 2% additional air is entrained above control mix at normal dosage

2.1.6. Micro Silica Fume (SF)

Micro silica was usedin SCC to attain durability. It contains silicon dioxide (SiO2) commonly exceeding than 85% in amorphous organism (non-crystalline) form.

SF is generally used at (5-15)% by weight of total cementitious material. Micro silica fume from United Arab Emirates under commercial name ***(Mega Add MS (D))*** it was utilized as substitution by weight of cement with (10%). The silica fume used in this work conforms to the physical and chemical requirements of***(ASTM C1240, 2005a)***.

2.1.7. Fibers

2.1.7.1. Steel Fibers

Ultra-fine steel fibers (ST) were utilized throughout the experimental work, this type of ultra-fine steel fibers was fabricated by the ***Ganzhou Daye Metallic Fibers Co., Ltd, China***. The properties of the used steel fibers are presented in Table 2.

Table (2) The properties of micro steel fibers used

Fiber type	Type	Surface	Density (Kg/m³)	Tensile Strength (Mpa)	form	Melting point (C°)	Average length (mm)	Diameter (mm)	Aspect ratio((L_f/D_f)
Micro Steel fibers(SF)	WSF 0213	Brass coated	7860	Minimum 2300	Straight	1500 C°	13	0.2±0.05	65

2.1.7.2. Polymer Microfibers (Polypropylene)

Micro polypropylene fiber (PP) was used . The properties of this fibers which had been used throughout the experimental work are shown in Table 3 .

2.1.8. OilProducts

In this investigation kerosene and gas oil were employed.

Table (3) Properties of the polymer microfibers

Specific Gravity	Length (mm)	Diameter (mm)	Young's modulus (MPa)	Water Absorption	Melting Point©	shape	Specific Surface (m^2/kg)	Tensile strength (N/mm^2)
0.91	12	0.032	3500-3900	Nill	160	straight	250	600-700

3. CONCRETE MIXTURES

This study aimed to make four mixes, three mixes inclusion fibers (FRSCC) and one is the control mix (SCC). The concrete was designed according to the***(EFNARC, 2005)*** method. Table 4provides the notation of mixes. A w/p (water/powder) of 0.3 was maintained for all mixtures, and the dose of high-range water-reducing admixture was also kept constant.

By keeping mixture variables constant and varying only the fiber parameters, the goal was to assess the influence of fibers which were utilized with different types on characteristics of FRSCC when exposed to the oil products. The ideal dose of HRWRA of 2.5/100 kg of cement was specified by employing slump flow test and other tests of self-compacting concrete. The dosage of HRWRA used in this study was (3.5%) of cementitious materials for all mixes. Steel-fibers (ST) were used in percentage of (0.75), polypropylene fibers (PP) by (0.1%), and hybrid PP. and ST fibers by (0.05 and 0.7)% of total volume for mixes. Fibers were supplied into the mixer through the hand to include that gathering and clustering effects were reduced.

Different trail mixtures were implemented to specify the appropriate dose of superplasticizer to satisfy SCC requirements that give standard of filling ability, passing ability and segregation resistance, then the amounts of materials were changed until attaining a favorable self-compactability by assessing tests of fresh concrete with compressive strength about (70 MPa) at 28 days, as shown in Table (5).

Table (4) Notation of mixes

Mix Notation	Details
RS	Reference mix of SCC without fibers
PS	Mix of SCC with 0.1 of polypropylene fibers of concrete volume
ST	Mix of SCC with 0.75% of micro steel fibers of concrete volume
HS	Mix of SCC with hybrid of (0.7 ST +0.05 P.P) of concrete volume

Table (5) Details of SCC and FRSCC mix used in this investigation

Cement Kg/m³	Sand Kg/m³	Gravel Kg/m³	L.S.P Kg/m³	S.F Kg/m³	Water Kg/m³	SP by Wt. of cm. Kg/m³	W/b	W/cm
450	850	800	80	50	175	17.5	0.3	0.35

4. MIXING PROCEDURE

In this research Emborg mixing manner ***(Emborg, 2000)*** is substantial to achieve the required homogeneity and workability of the concrete mix. SCC is mixed in a rotary laboratory mixer with a ability of (0.08 m³). In this study, which is summarized outlined in the next points:

- The 1/3 quantity of water and dose of superplasticizer, were added with fine aggregate to the mixer, and mixed for (1 minutes).
- Another 1/3 quantity of water and dose of superplasticizer was added to the mixture with cement and mineral admixture then the mixture is mixed for (0.5 minute).
- Thereafter, the last 1/3 quantity of water and the dose of superplasticizer was added to the half quantity of coarse aggregate and mixing for (1 minute) then the mix was rested to (0.5 minute) .
- Finally the residual half quantity of coarse aggregate was added to the mixer, the entire time of mixing more than (5 minute).
- The mixture was then discharged tested, casted in mold and cured for 28 days.

5. TYPES OF EXPOSURE TO OIL PRODUCTS

After curing, some of these samples were left to dry in the temperature of room (27 Cº) for two days only. Then, some of these samples were exposed to gas oil and the others samples were exposed to kerosene at different periods of exposure (30, 60, 90 and 180 days).

6. TESTS OF FRESH CONCRETE

The self-compacting concrete has high flowable and consistency, so that the traditional procedure to measure workability cannot be used for this property. Many researchers and agencies use slump flow test, , V- funnel test, T_{500mm} test, and L-box test were utilized as test method for properties of workability for SCC. These test methods are shown in the methods European federation dedicated to specialist construction chemical and concrete system SCC guide lines ***ERMCO, 2005***

7. TEST OF HARDENED CONCRETE

7.1. Compressive Strength

The compressive strength was executed according to ***(BS. 1881: Part 116: 1989)***. Cube (100*100) mm were examined by utilizing a machine of hydraulic compression 1900 kN, at rate of loading by 18 MPa per minute. The average of compressive for three cubes was calculated at each test was carried out at ages of (28, 60, 90, 120 and 210) days for specimens submerged in water and oil product, in other word at period of exposure of (30, 60, 90, 180) days for specimens exposed to oil products.

7.2. Splitting Tensile Strength

The splitting tensile strength was determined according to ***(ASTM C496, 2004)***, by using cylinders of (100×200) mm. Two slim plywood bars were located above and below the specimens which was placed between bearing blocks, which was a machine of hydraulic compression 1900 kN. A diametral force of compressive was applied on a cylindrical concrete specimen length at a rate of 1.4 MPa per minute until the collapse occurs.

7.3. Total Absorption

The total absorption measurements were conducted on (100*100*100) mm cubes according to ***(ASTM C642-2003)*** . The specimens were dried in an oven at a temperature of (100-110 ^{0}C) for 24±2 hrs. Then, the specimen was taken out and weighed. After that, the specimen was fully immersed in wateror oil products for 48 hours, then removed and surfaces dried with a cloth and the specimen was weighed again.

7.4. Ultrasonic Pulse Velocity test (U.P.V.)

Concrete cubes of 100 mm were utilized to standardize the propagation longitudinal velocity wave pulses through concrete. The experiment was carried out according to ***(ASTM C597, 2002).*** Immediate transducer configuration was applied and longitudinal pulses stress wave were created by electro- acoustical transducer that was held in touch with one concrete surface under test. Next navigating out of the concrete, the pulses were arrived and transformed into energy of electrical through a second transducer. The equation of pulse velocity is given below:

$$\boldsymbol{v} = \frac{\boldsymbol{L}}{\boldsymbol{T}} \dots \text{(1)}$$

Where:

V: pulse velocity, (km/sec), L: distance between center of transducer faces, (mm) , T: time of transit, (μsec).

8. RESULT AND DISCUSSION

8.1. Fresh properties of SCC and FRSCC

Fresh properties of the control mix SCC and FRSCC mixes were evaluated by the tests and compared with the standard criteria. The workability tests were made on fresh mixes instantly after mixing comprehensive slump flow and T_{500mm} test, V-funnel, V-funnel at $T_{5minute}$ and L-box tests, which are complying with the requirements of the typical acceptance criteria for SCC for all mixes. Table (6) clarifies the amounts of fresh tests to the control mix and other mixes in present study.

Table (6) Result of fresh test for all mixes

Set No.	Dosage of S.P Kg/m^3	Slump flow (mm)	T_{500} (Sec.)	L-Box blocking ratio (H_2/H_1)	V- Funnel Time (Sec.)	V- Funnel Time at T_{5min}. (Sec.)	Segregation Index (visual)
RS	10	500	9	0.66	14	21	Stiff homogenous
	12.5	550	7	0.72	12	18	homogeneous
	14	615	6	0.78	11.5	17	homogeneous
	15	720	4	0.8	9	15	homogeneous
	17.5	775	2.5	0.92	8	9	homogenous
	20	818	2	0.96	5	7	Slight bleeding
PS	17.5	730	3	0.87	8	12	homogeneous
ST	17.5	720	4	0.84	11	15	homogeneous
HS	17.5	710	5	0.83	11	16	homogeneous

8.2. Hardened Properties of SCC and FRSCC

Properties including, compressive strength, splitting tensile strength, UPV, and total absorption of the selected SCC and FRSCC mixes were studied after exposure to water and oil products such as kerosene and gas oil for different periods of exposure (30, 60, 90, and 180days).

8.2.1. Compressive Strength

The compressive strength results of concrete specimens for control mix (SCC) and others mixes reinforced with several types of fibers (FRSCC) cured in tap water at ages of 28 days and exposed to water and products of oil up to 180 days aresummarized in Table (7). These relations are shown by the graphical representations in Figures from (1) to (4).

The test results show that whole samplesimmersed in water exhibit a persistent enhance in the compressive strength as the period of immersion is increased. This development in the compressive strength for these specimens is because of the extended the process of hydration which combine a new product of hydration inside the mass of concrete then increases the bond between cement paste and aggregate, these results agree with that of ***(Al harbi, 1998***and***Neville 2010)***. Additionally good interfacial bond between cement paste and aggregate and between steel fibers and matrix with the increase of time of curing in water. Also the presence of the silica fume in self-compacting concrete (SCC) improves the strength and increases particle packing density according ***(De Larrad, F., 1994)***.Also replenish in the capillary pores and promote the characteristic of the interfacial transition zone (ITZ) and microstructure of the cement matrix due to the motivation of pozzolanic and improves the bond between aggregate and cement paste, this is also suggested by ***(Tanyildizi, 2009).***

This property for specimens from all types of mixes exposed to products of oil for 30 days does not show any noticeable change in a comparison with the same specimen from the same mixture which exposed to water at the same exposure period. This is result from the pores which were remaining relatively filled by water and lead to additional hydration that delay the deterioration of specimens according to view of ***(Abdul-Moghni, 1999)***.The compressive strength for SCC and FRSCC specimens minimized as the time of exposure to oil products maximized.

The deterioration in compressive strength perhaps due to predicate to the weakening in the bond strength between cement paste and aggregate and between cement matrix and fibers with increase the time of exposure. This deterioration due to infiltration of those liquids into microstructure of heterogeneous concrete and caused the expansion of gel pores and dispersion components of solid hydration, moreover to accretion the internal pressure lead to readily sliding of particles. Besides, reduction occurs in power of surface due to infiltration these liquids lead to the reduction in compressive strength, it complied with same conclusions ***(Al harbi et al., 1998)***.

The results indicated that (HS) mix revealed lower reduction in compressive strength that compared with other mixes after exposure to oil products.

Table (7) Average results of compressive strength for whole mixtures at the diverse periods of soaking in oil products and water exposure

Set No.	Compressive strength for whole mixes after different durations of exposure (MPa)											
	Exposure durations (Age) days											
	30(60)			60(90)			90(120)			180(210)		
	Water	Kerosene	gas oil	water	Kerosene	gas oil	Water	kerosene	gas oil	water	Kerosene	gas oil
RS	78.10	78.92	77.78	81.10	74.73	73.08	82.58	70.28	69.15	85.0	68.28	67.22
PS	81.0	80.04	79.91	83.40	75.60	74.95	85.27	72.29	71.01	86.16	70.95	68.58
ST	86.33	86.90	85.82	87.80	84.32	81.13	88.74	81.85	79.70	91.41	75.10	73.54
HS	87.93	87.33	86.97	88.20	83.57	82.98	90.15	82.05	79.58	91.77	76.84	74.02

8.2.2 Splitting Tensile Strength

The tensile strength for concrete is considerably minimal than the compressive strength because of the facility with cracks which diffuse under tensile loads. However, it is a significant property, since extremely cracks concrete is commonly appear due to the tensile stresses that happen under load, the concrete collapse in tension is predominate by microcraking correlating especially with the interfacial transition zone (ITZ) ***(Druta, 2003)***.

Table (8) shows the results of splitting tensile strength test for control mix (SCC) and other mixes reinforced with several types of fibers (FRSCC) for specimens cured in tap water at 28 days of age before exposure to water and oil products up to 180 days and these relations are shown in the graphical representations through Figures from(5) to(8).

Usually, the results indicate that the splitting tensile strength for all types of mixeswhich exposed to oil products for 30 days do not show any noticeable change in comparison with specimen from the same mixture which exposed to water at same exposure period. The deterioration in splitting tensile strength result after exposure period of 60 days or more from reasons as aforementioned above in compressive strength behavior.

The results elucidated that (HS) mix reveal lower reduction on splitting tensile strength when compared with other mixes after exposure to oil products.

Table (8) Average splitting tensile strength results for whole mixtures at the diverse periods of soaked in oil products and water exposure

Set No.	Splitting tensile strength for all mixes after varied periods of exposure (MPa)											
	Exposure duration (Age) days											
	30(60)			60(90)			90(120)			180(210)		
	Water	Kerosene	gas oil	water	Kerosene	gas oil	Water	kerosene	gas oil	water	Kerosene	gas oil
RS	6.09	6.13	6.07	6.52	5.72	5.32	6.74	5.43	5.11	7.11	4.81	4.45
PS	6.54	6.52	6.48	6.6	6.23	5.86	6.69	6.11	5.38	6.75	5.75	5.21
ST	9.77	9.62	9.52	9.81	9.12	8.79	10.02	8.53	7.74	10.31	7.68	7.23
HS	9.63	10.05	9.55	9.75	8.85	8.10	9.98	8.05	7.61	10.41	7.45	7.11

8.2.3. Ultrasonic Pulse Velocity (UPV)

The results of test for ultra-pulse velocity (U.P.V.) were measured on (100 mm) cubes and used in order to study the variations of ultrasonic pulse velocity of concrete and use to determine the level of damage in concrete when exposed to products of petroleum with different ages of exposure (30,60, 90, and 180) days and cured to 28 days in water before exposure as compared with those specimens curing continuously in water for the same ages.

The U.P.V results for all specimens types is cured in tap water at 28 days age, It shows that the U.P.V for concrete mixes (with or without fibers) is increased with the time of curing in water increased. Table (9) and Figure from (9) to (12) depictthe effect of the exposure at various periods to water and oil products on U.P.V value for all kinds of mixes used in this study.

The progress in (UPV) is harmonious with hydration reaction of concrete and the bond strength between aggregate and cement paste. The velocity along fiber established in concrete was additional influenced by the velocity of pulses in concrete mass and the circumstance of the fasten between steel and concrete ***(Nik, A.S. and Omran, O.L, 2013)***.

After exposure period of 60 days or more, the percentages of ultra-pulse velocity for total mixes exposed to oil products (gas oil and kerosene) were decrease comparatively with time as compared with the same mixtures soaked in water at the similar exposure periods. As aforementioned from reasons in the previous properties and through the graphical representations which explain the behavior of all mixtures after exposure to oil products with compared with the same specimens curing in water for the same period of exposure.

The presence of steel, polypropylene, and hybrid (steel plus polypropylene) fibers in SCC results in an increase in ultrasonic pulse velocity, and this is consistent with the researcher's opinion ***(AL-Ridha, 2016 and Shendge et., al, 2017)*** found a similar trend that ultrasonic pulse velocity developed due to the containment of fibers.

Table (9) Average ultrasonic-pulse velocity results (U.P.V) of whole mixes at the diverse periods of soaked in products of oil and water exposure

Set No.	Average ultrasonic-pulse velocity results (U.P.V) for whole mixes after various periods of exposure (U.P.V) (Km/Sec.)											
	Exposure duration (Age) days											
	30(60)			60(90)			90(120)			180(210)		
	Water	Kerosene	gas oil	water	Kerosene	gas oil	Water	kerosene	gas oil	water	Kerosene	gas oil
RS	4.63	4.64	4.63	4.68	4.62	4.60	4.74	4.60	4.57	4.81	4.54	4.50
PS	4.78	4.79	4.77	4.80	4.75	4.73	4.84	4.70	4.69	4.90	4.63	4.58
ST	4.85	4.84	4.83	4.87	4.81	4.79	4.90	4.77	4.73	4.96	4.71	4.65
HS	4.83	4.85	4.81	4.86	4.83	4.79	4.91	4.80	4.74	4.95	4.72	4.65

8.2.4. Total Absorption

The results of tests for total absorption for control mix (SCC) and (FRSCC) after exposed to oil products are presented in Table (10). Results of test refers to all specimens soaked in water minimize the total absorption for its continuously with the progress of age.

The graphical representations from (13) to (16) refer that the total absorption for all mixtures continuously exposed to different oil products increases as the period of exposure to those product increases. This is result from the deleterious impacts of oil products on concrete microstructure and the bond between aggregate and cement paste that cause increment in the porosity and then increase the concrete absorption.

Generally, the test results of total absorption for the prepared mixes of specimens at any time continuously immersed in gas oil was less than total absorption for same specimens continuously immersed in kerosene, this is because of the higher viscosity that are found in the chemical composition of gas oil with compared to kerosene product which may decrease the permeability of concrete by blocking some of pores which is confirmed by other investigations such as ***(AL-Swaidawi, 2013), and (Weli, 2016)***.

The permeability of FRSCC minimizes considerably when compared with the permeability of SCC , this is attributed to the breakage of porous by the reinforcement of fibers mechanism which is confirmed by other study such as ***(Singh A, Singhal D, 2011 and Afroughsabet et. al, 2017)***.

Table (10) Average of total absorption for whole mixtures at the diverse periods of soaked in oil products and water exposure

Set No.	Total Absorption for whole mixtures after varied exposure periods (%)											
	Exposure duration (Age) days											
	30(60)			60(90)			90(120)			180(210)		
	Water	Kerosene	gas oil	water	Kerosene	gas oil	Water	kerosene	gas oil	water	Kerosene	gas oil
RS	2.43	0.79	0.68	1.91	0.99	0.73	1.34	1.11	1.07	1.31	1.55	1.47
PS	2.38	0.75	0.63	1.75	0.84	0.70	1.32	1.09	1.02	1.27	1.49	1.43
ST	2.27	0.71	0.60	1.72	0.74	0.65	1.32	1.0	0.91	1.19	1.35	1.22
HS	2.26	0.64	0.58	1.75	0.71	0.64	1.34	0.98	0.89	1.20	1.32	1.18

9. CONCLUSIONS

Depending on the experiential investigation of this study and the interpretation of the consequence, the following conclusions are drawn as follows;

- The reduction in compressive strength of control mix (SCC) for exposure periods after 30 daysup to 180 days for submerging in gas oil and kerosene respectively in comparison with the same kind of mix immersed in water at the same age is (20.91%, and 19.67%), while the reduction in FRSCC such as PS is (20.41 %, and 17.65%) , whereas the reduction in ST is (19.54 %, and 17.84%), and the reduction in HS is (19.34 %, and 16.26%).
- The reduction in the splitting tensile strength for control mix (SCC) for exposure periods up to 180 days for submerging in gas oil and in kerosene respectively in comparison with the same kind of mix immersed in water at the same age is (37.41%, and 32.34%), while the reduction in FRSCC such as PS is (22.81%, and 14.81%), whereas the reduction in ST is (29.87%, and 25.51%), and the reduction in HS is (31.70%, and 28.43%).
- The reduction in ultrasonic pulse velocity for control mix (SCC) for exposure periods up to 180 days for submerging in gas oil and kerosene respectively in comparison with the same kind of mix immersed in water at the same age is (6.44%, and 5.61%), while the reduction in FRSCC such as PS is (6.53%, and 5.51%), whilst the reduction in ST is (6.25%, and 5.04%), and the reduction in HS is (6.06%, and 4.64%).
- The total absorption to SCC and FRSCC samples soaked in the diverse products of oil developed as the time of submerge was increased. The percentage of increase for control mix (SCC) to interval of exposure between (60-180) days is about (0.73-1.47)%, and (0.99-1.55)% for submerging in gas oil and kerosene respectively, while the increment in FRSCC such as PS is about (0.7-1.43)%, and (0.84-1.49)%, whereas the increment in ST is about (0.65-1.22)%, and (0.74-1.35)%. Finally the increment in HS is about (0.64-1.18)%, and (0.71-1.32)%.
- The percentages of increment in compressive strength for FRSCC such as PS for exposure periods up to 180 days are (2.02%, and 3.91%), whilst the increment in STis (9.40%, and 9.98%).Finally the increment in HS is (10.11%, and 12.53%), for submerging in gas oil and kerosene respectively as comparison with the control mix soaked in the same conditions.
- The percentages of growing in splitting tensile strength for FRSCC such as PS for exposure periods up to 180 days are (17.07%, and 19.54%), whereas the increment in STis (62.47%, and 59.66%). Lastly the increment in HS is (59.77%, and 54.88%), for submerging in gas oil and kerosene respectively as comparison with the control mix soaked in the same conditions.

- The percentages of development in ultra-pulse velocity for FRSCC such as PS for exposure periods up to 180 days are (1.78%, and 1.98%), whereas the increment in STis (3.33%, and 3.74%). Finally the increment in HS is (3.33%, and 3.96%), for submerging in gas oil and kerosene respectively as comparison with the control mix soaked in the same conditions.
- The percentages of deficiency in total absorption for FRSCC as compared with the corresponding reference mix (SCC) soaked in the same conditions, such as PS for exposure periods up to 180 days is (2.72%, and 3.87%), whereas the diminution in STis (17.0%, and 12.9%). Finally the reduction in HS is (19.72%, and 14.83%), for submerging in gas oil and kerosene respectively.

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