Effect of Curing Condition on the Engineering Properties of Fiber Reinforced Concrete

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Abstract

The paper reports an experimental study investigating the influence of curing conditions on the engineering properties of fiber reinforced concrete (FRC) . Portland cement (P_C) concrete and two types of FRC , i.e. SFRC with 1% by volume steel fiber reinforcement and PFRC with 1% by volume poly propolylene reinforcement specimens are prepared and cured in two different curing conditions , namely water and air conditions for the periods of 3,7,14 and 28 days . At the end of each curing periods , compressive and tensile strength and ultrasonic velocity (UPV) values are determined . The results showed that water curd specimens always give the highest values then air condition irrespective of type and age of concrete and test method for both compressive and tensile strength tests , the PFRC gives the highest values followed SFRC and then P_C concrete for all curing periods and conditions , also , the UPV results showed that the highest values are obtained from the PFRC and then from the SFRC and P_C concrete for all curing conditions .

Keyword:(Steel Fiber ,Polypropylene Fiber ,Curing ,Tensile Strength , compressive strength **)**

الخلاصة

يبين البحث دراسة عملية لتأثير طرق المعالجة على الخصائص الهندسية للخرسانة المسلحة بالألياف وكونكريت الأسمنت البورتلاندي ، لقد استخدم الأسمنت البورتلاندي مع نوعين من الألياف المسلحة وبنسبة حجميه 1% من ألياف الحديد و1% من ألياف البولي بروبلين تم تحضيرها معالجتها تحت ظروف مختلفة متمثلة بالماء أولا وبالهواء ثانيا وبفترات 3، 7،14 و28 يوم . وفي نهاية كل فترة معالجة تم تعيين مقاومة الشد والانضغاط وسرعة الأمواج فوق الصوتية . لقد بينت النتائج أن النماذج المعالجة بالماء أعطت قيم أعلى من النماذج المعالجة بالهواء بغض النظر عن نوع وعمر الكونكريت وطريقة الفحص لكلتا الخاصيتين الانضغاط والشد . أن الخرسانة المسلحة بألياف البولي بروبلين أعطت قيم عالية مقارنة بالخرسانة المسلحة بألياف الحديد وخرسانة الأسمنت البورتلاندي لكل فترات المعالجة . وهدا ما أظهرته نتائج فحص الأمواج فوق الصوتية ولكل ظروف المعالجة.

Introduction:

Fiber reinforced concrete (FRC) may be defined as a composite materials made with Portland cement , aggregate and incorporating discrete discontinuous fibers . It may also contain pozzolans and other admixtures commonly used with conventional concrete (Mehta and Montero 2006).Fibers are usually produced from different materials ranging from steel , plastic , glass and natural materials , however for most structural and non structural purposes , steel fibers is the most commonly used of all the fibers.

Plain , un reinforced concrete is a brittle materials with a low tensile strength and a low strain capacity . To overcome these deficiencies , additional materials are added to improve the performance of concrete .

The type of fiber and its volume fraction has market effect on the properties of fiber reinforced concrete . It is convenient to classify the fiber reinforced composites as a function present as(Mehta and Montero 2006) .

Extensive research on fiber reinforced began in 1960(Ramualai and Mandel 1964) and since then substation amount of researches development , applications and commercialization have occurred(Van chanh 2005,Nataraja et al. 2001,and shakir 2008). Akinkurolere 2010, investigated the effects of steel fibers on the splitting tensile and compressive strength stress strain relationship (stiffness) of recycled

aggregate concrete . Concrete mixtures comprised concrete mix , prepared without the addition of steel fibers , and concrete mixes reinforced with different water cement ratio , recycled aggregate , fly ash and steel fiber volume . Obtained results show that the addition of steel fibers do not usually have a major effect on the compressive strength of concrete that can add a little to the splitting tensile strength of concrete .

Matasher and Abass 2011, investigated the effects of polypropylene fiber on the compressive and flexural strength of normal weight concrete results indicated that the increase of mechanical properties resulting from added of polypropylene fiber was relatively high . Whilst Ramadoss , et.al. 2008, have developed equations for predicting 28 days tensile strength of high performance concrete in term of fiber reinforcing index .

Proper curing plays a significant role in a achieving optimum performance full potential from a given concrete mixture (BCA 1993) . The research carries out by Bentz et.al. 1997, showed that curing conditions have significant effect on the degree of hydration of cement . They showed that the specimens (initially cured at 100% RH 6 or 12 hr) exposed to 90% RH by duration process discontinued 95 all remaining capillary water was lost due to evaporation , whist curing under sealed condition , in particular for concretes with w/c of 0.4 or over or keeping the surface as saturated were adequate .

The aim of this investigation is to study the influence of different curing conditions on the compressive and tensile strength of FRC by using two type of fiber reinforcements in comparison with normal Portland cement (P_C) concrete by using well established test methods .

Experimental Work

Two different fiber – reinforced mixes and one plain concrete mix were cast using ordinary Portland cement , local sand and local gravel with maximum size of 19 mm . Each series contained the same mix properties of 1 cement : 1.5 sand : 3 gravel in proportion by weight and water / cement ratio of 0.5 . Steel fiber was added to mix SFRC and polypropylene fiber was added to mix PFRC . The fiber volume fraction was held constant at 1% for all FRC mixtures . Details of the fiber are given in Table((1)) .

Table ((1)): Fiber properties.

Fiber type	Fiber length (mm)	Fiber diameter (mm)	Nominal ultimate strength (Mpa)
Hooked steel fiber	25	0.5	1130
Fibrillated polypropylene	12	0.018	450

Standard 100 mm cube and cylindrical with diameter of 150 mm and a height of 300 mm specimens were produced for compressive strength according to BS.-118and to splitting tensile strength according to BS-117respectively . In the following day of casting , the specimens were de-molded and located in two different curing conditions , namely water and dry cured for the periods of 3,7,14 and 28 days . At the end of each curing period ,a total of 3 specimens were tested for each concrete property.

The compressive strength and ultrasonic pulse velocity (UPV) , time required for the pulse to pass from one side to the other side of the specimens , whilst the splitting tensile test were carried out on the cylindrical specimens . All the test performed during this research were conducted 3,7,14, and 28 days for all curing conditions . The performance of FRC have be examined with respect to relevant properties of plain PC concrete .

Result and Discussion

Compressive Strength:

The results obtained from compressive strength tests for plain (P_C) concrete , PFRC and SFRC for all concrete ages and curing conditions are given in Figures ((1,2,3)) respectively . It can seen in this figures that the compressive strength results of PFRC and SFRC specimens were higher than those of corresponding P_C concrete specimens for all curing methods . It is also indicated the heights compressive strength values were obtained from eater cured specimens then air cured specimens regardless of the concrete types . This shows the role of curing methods on the early age compressive strength of concretes , i.e. , the higher the moisture level the specimens were exposed to the higher to compressive strength was achieved . When the fiber reinforced concrete are compared , it can be seen that the PFRC contain 1% steel fiber reinforcement provided compressive strength higher than those of PFRC contain 1% polypropylene reinforcement , regardless of curing conditions . Steel fiber showed little effect on the compressive strength of plain concrete . Whilst the increase was about 51.4 percent for compressive strength when polypropylene reinforcement are used .

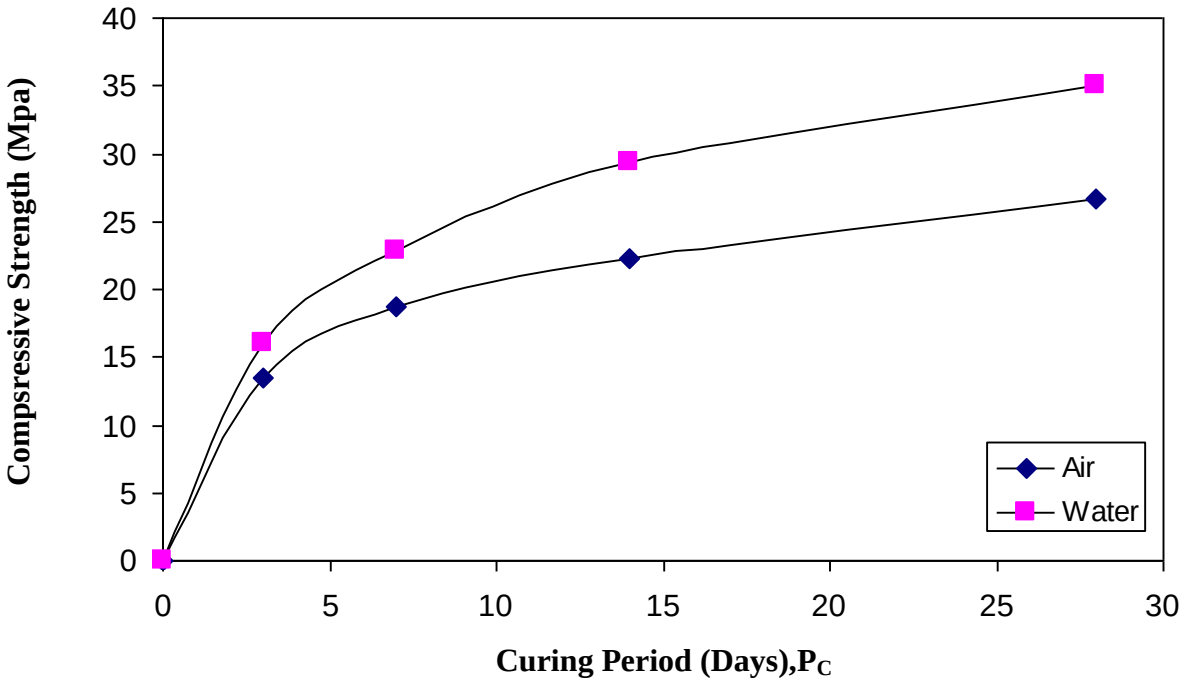

Fig. (1) Compressive Strength Results for Portland Cement Concrete (P_C)

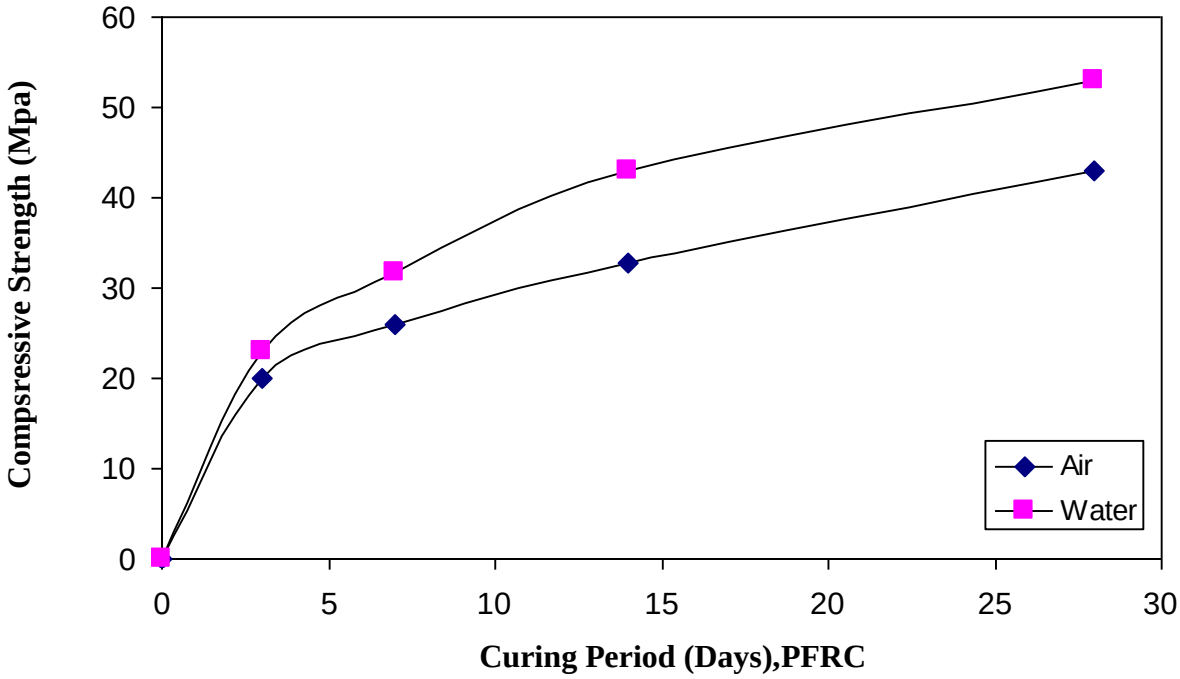

Fig. (2) Compressive Strength Results for Polypropylene Fiber Reinforced Concrete (PFRC)

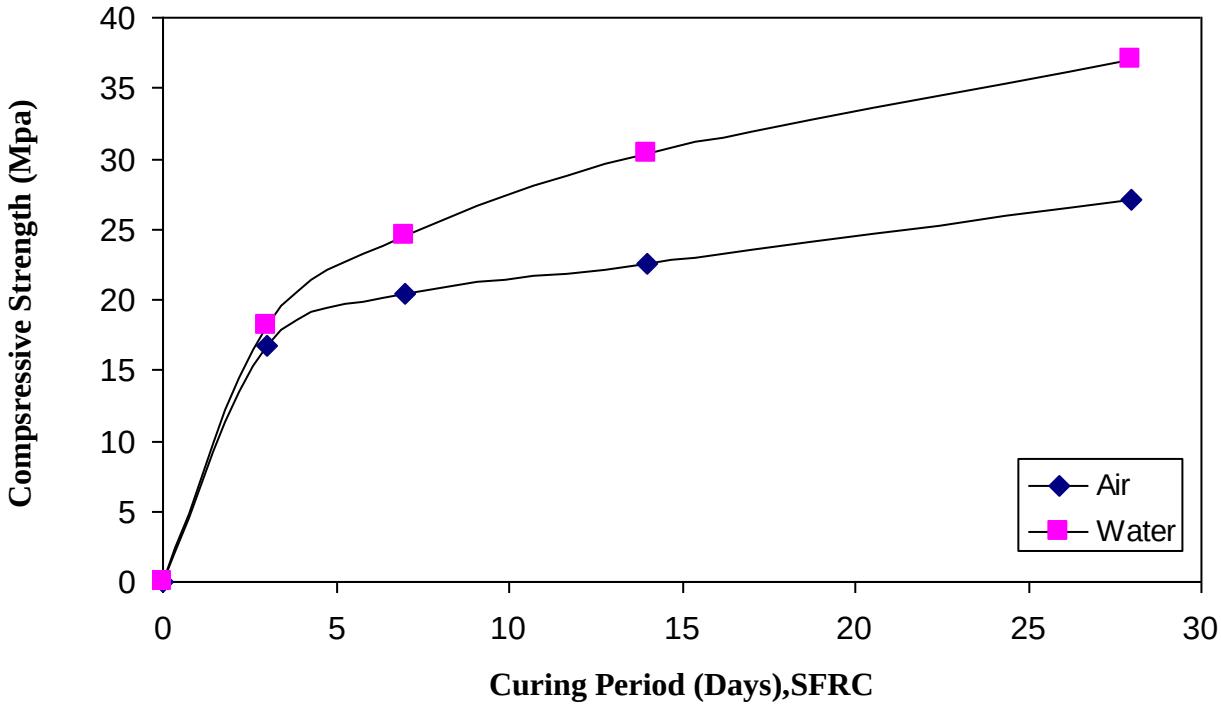

Fig. (3) Compressive Strength Results for Steel Fiber Reinforced Concrete (SFRC)

Tensile Strength

The tensile strength results for three types of concrete , P_C and PFRC and SFRC in two different curing methods for the 3, 7,14 and 28 days curing periods are shown in Figures((3,4,6)) respectively . This indicated in this figures that the development of tensile strength of plain P_C concrete was the lowest followed by SFRC and PFRC . Figure((4)) shows that use of 1% polypropylene fiber contributed significantly to the tensile strength particularly in the early ages , when the influence of curing methods on the tensile strength of concretes are examined , it can be seen that the highest values were obtained from water cured specimens , then air cured specimens , regardless of concrete types for splitting tensile strength the increase was about 46.15 when 1% polypropylene are used whilst the increase was 30.7 percent when 1% steel reinforced are used

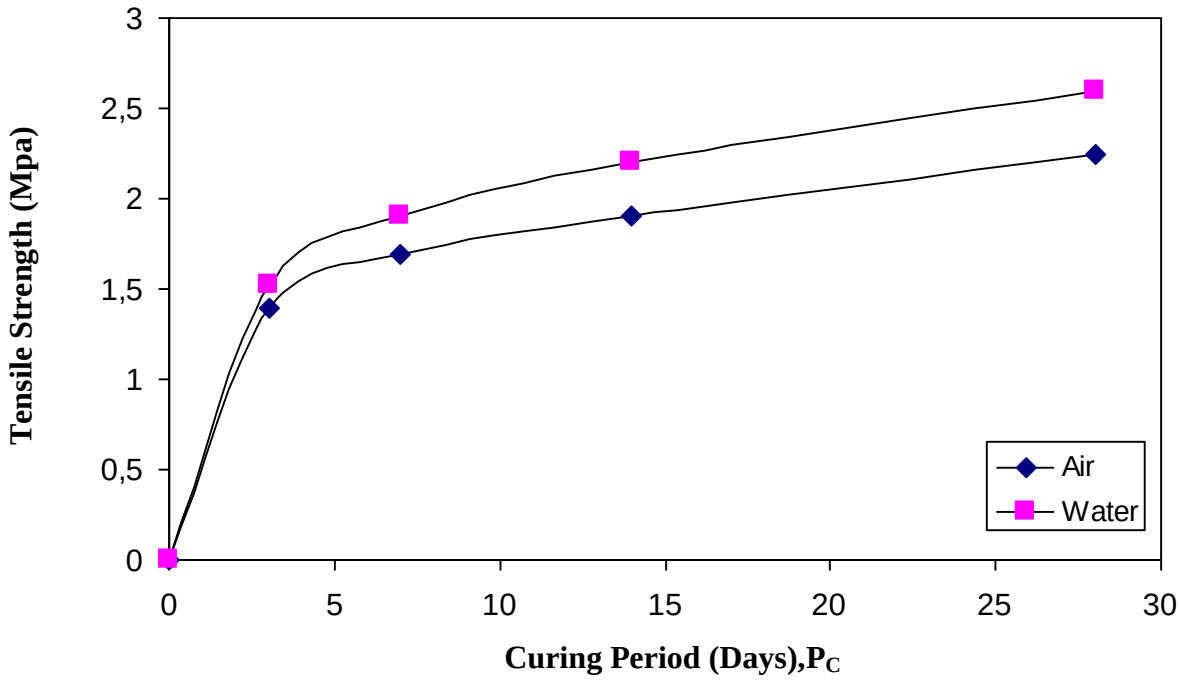

Fig. (4) Tensile Strength Results for Portland Cement Concrete (P_C)

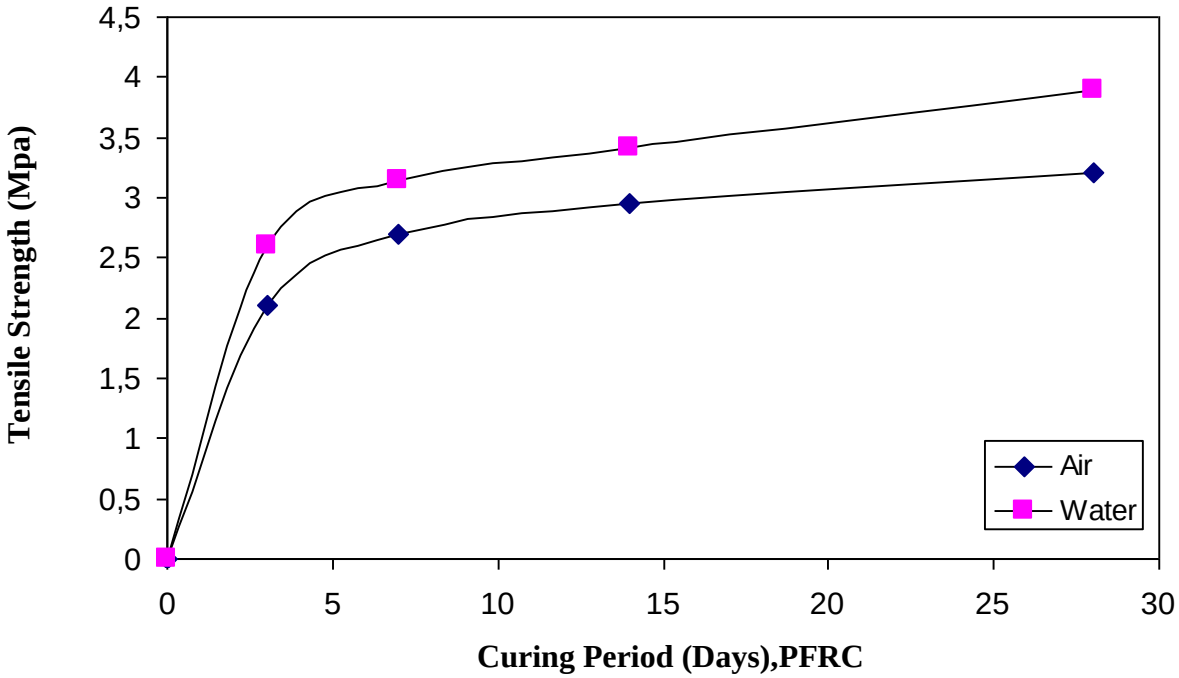

Fig. (5) Tensile Strength Results for Polypropylene Fiber Reinforced Concrete (PFRC)

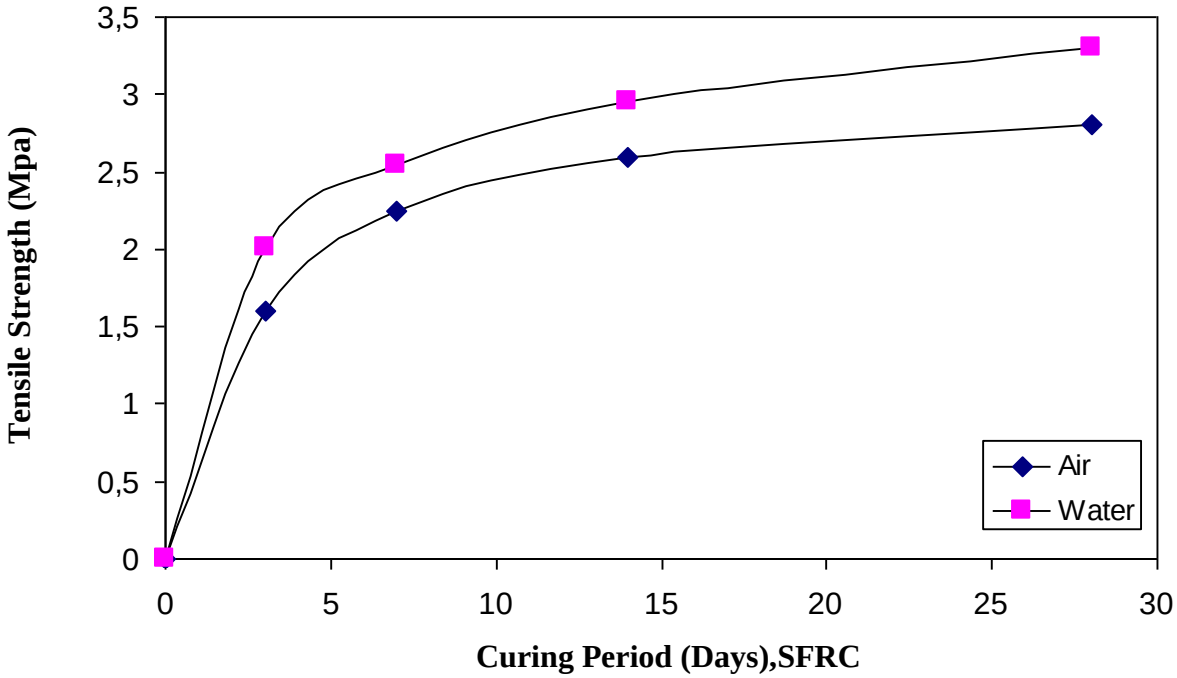

Fig. (6) Compressive Strength Results for Steel Fiber Reinforced Concrete (SFRC)

Ultrasonic Pulse Velocity:

Figure((7,8,9)) , give the UPV test results for PC and SFRC concretes , respectively at 3,7,14 and 28 days for all curing conditions . The highest UPV values were obtained from the PFRC followed by SFRC and PC concrete .

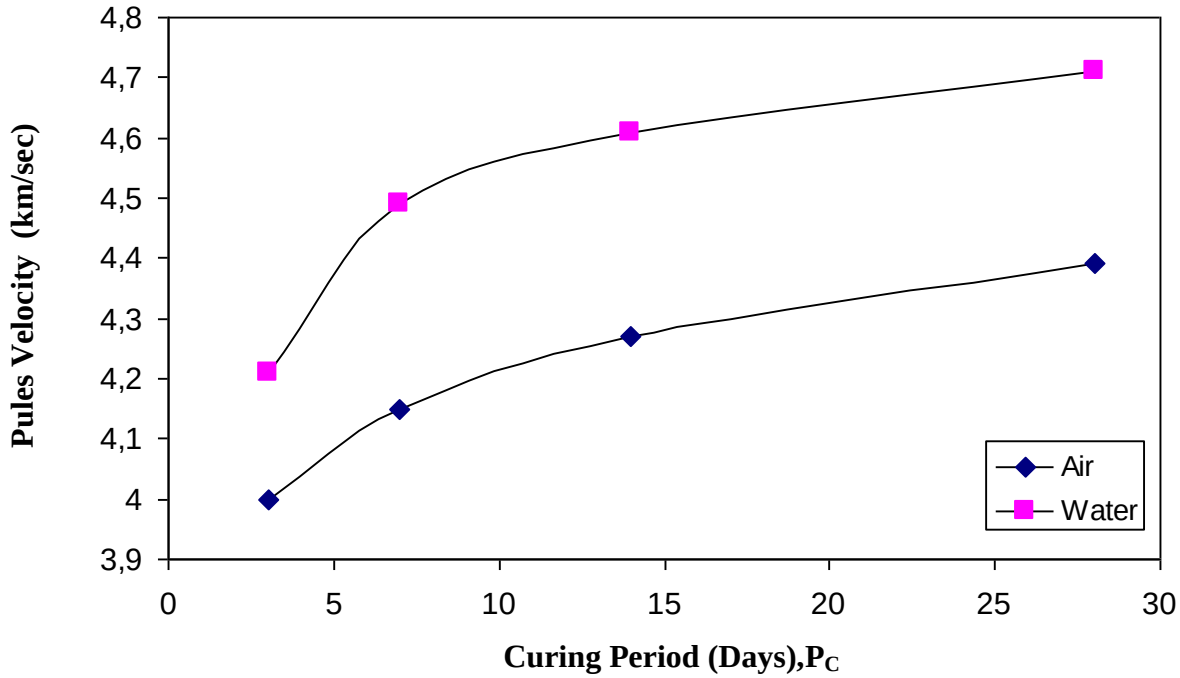

Fig. (7) Ultrasonic Pulse velocity Results for Portland Cement Concrete (P_C)

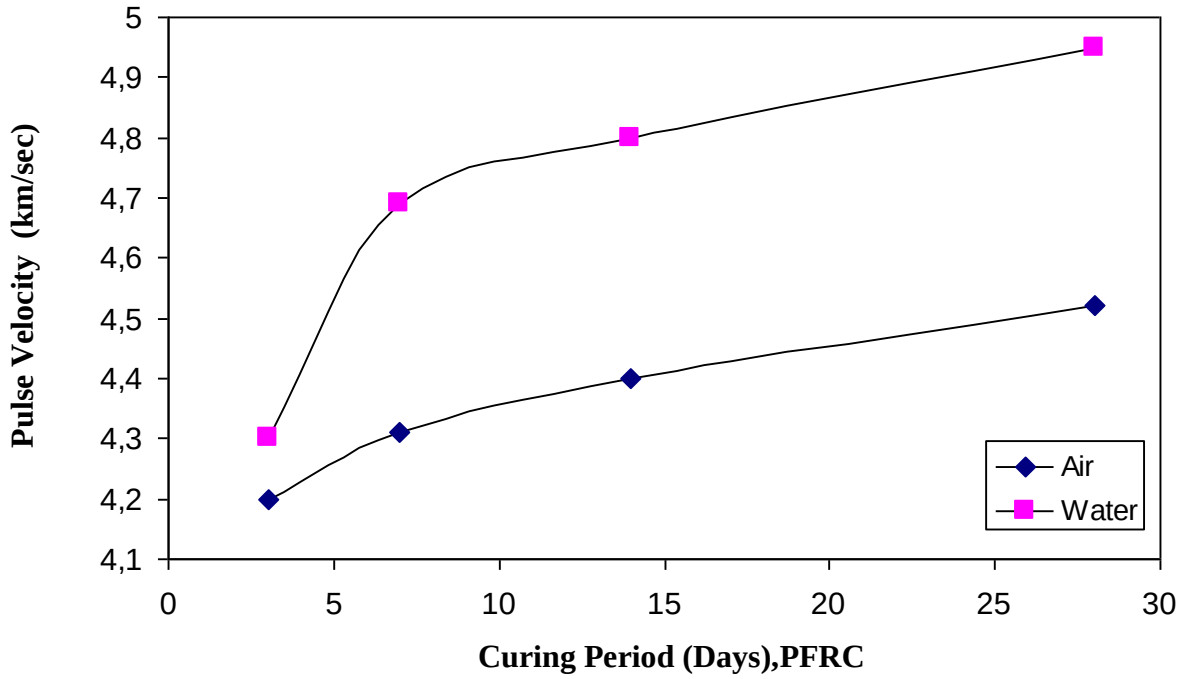

Fig. (8) Ultrasonic Pulse velocity Results for Polypropylene Fiber Reinforced Concrete (PFRC)

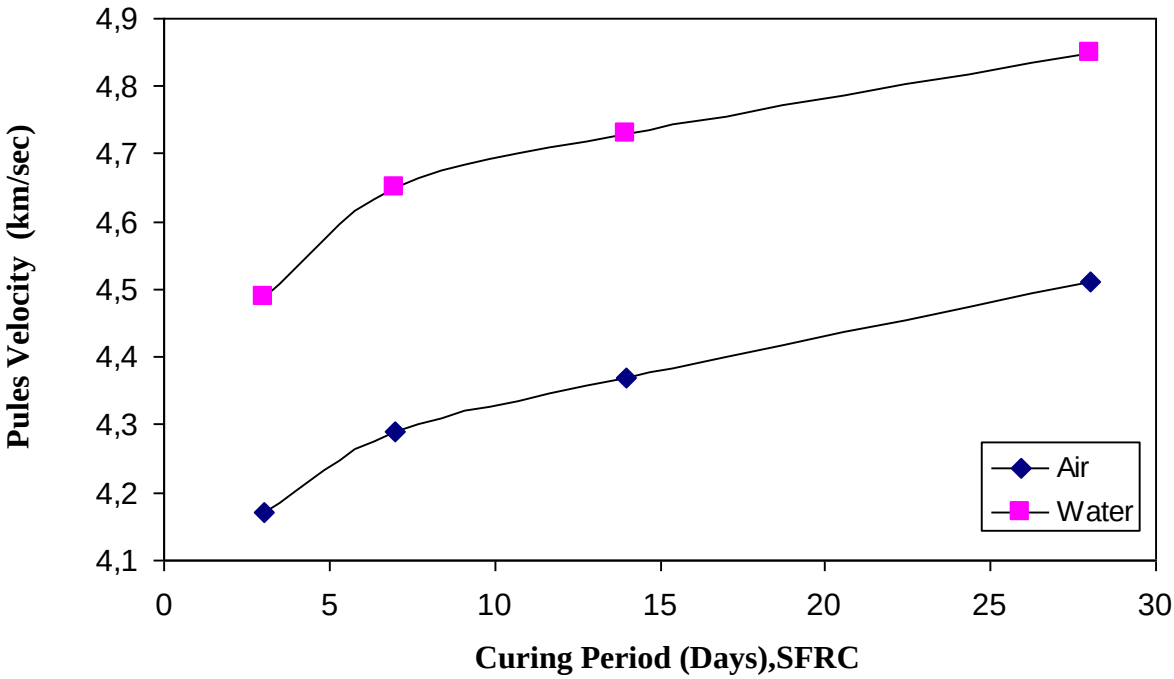

Fig. (9) Ultrasonic Pulse velocity Results for Steel Fiber Reinforced Concrete (SFRC)

Water cured specimens for all concrete types gave the highest values then air curd specimens again indicating the role of moisture level on the hydration and strength development .

Comparison of Tensile and Compressive Strength:

The tensile and compressive strength results of PO , SFREC , PFRC concrete s are compared in figure((10)) , on the basis of the curing method applied . It is indicated in this Figure that as the compressive strength of concrete increased , the tensile strength also increased .

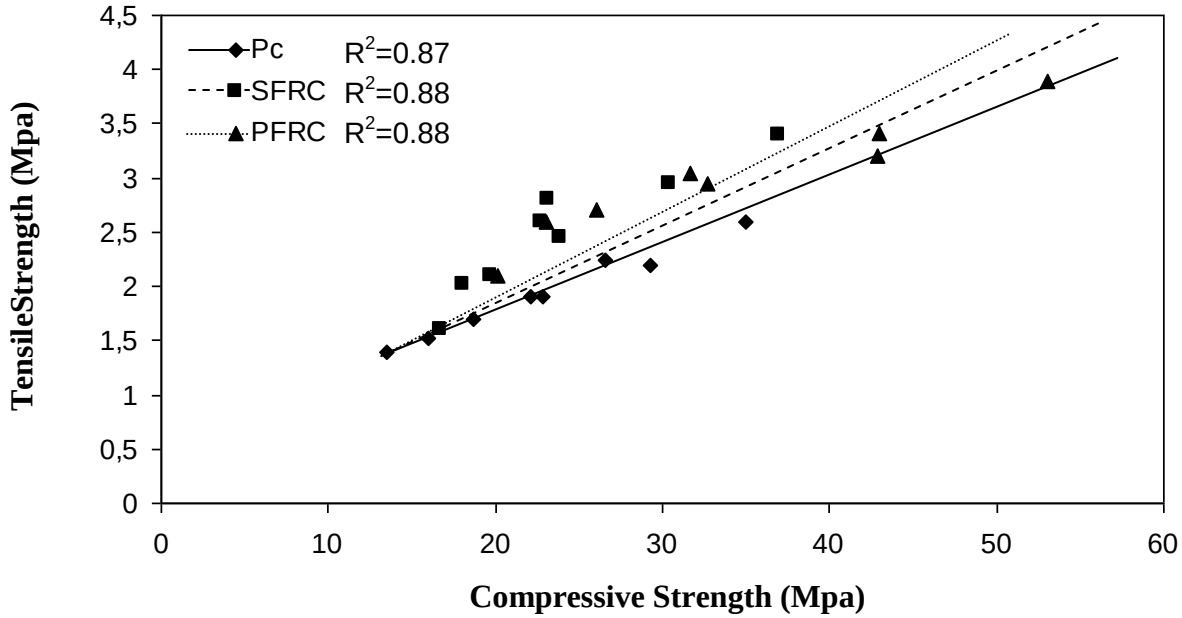

Fig. (10) Comparison of Compressive and Tensile Strength of Concretes

On the basis of curing method applied . It is indicated in this figure that as the compressive strength of concrete increased , the tensile strength also increased . It is also shown that at the lower strength levels , i.e. at early ages there was not big defenses between the tensile strength values of different concretes . However , as the compressive strength increased , difference between the tensile strength values started to appear .

Conclusions

On the basis of the experimental investigation carried out the following conclusions can drawn:

1- For all concretes , the water cured specimens gave highest compressive and tensile strength .
2- The compressive and tensile strengths of FRC were higher than those of P_C concrete for all testing ages and for all curing conditions .
3- PFRC containing 1% polypropylene reinforced fibers gave the highest UPV values followed by SFRC and the P_C concretes .
4- Polypropylene fiber inclusions in amount of 1% increased the compressive strength up to 51.4% and splitting tensile strength up to 49.6 % .
5- The addition of steel fiber added a little to the compressive and splitting tensile strength of concrete

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