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Foreword

Alhamdulillah. First of all a big thank you and congratulations to the Editorial Board of *Esteem Academic Journal* of Universiti Teknologi MARA (UiTM), Pulau Pinang for their diligent work in producing this issue. I also would like to thank the academicians for their contributions and the reviewers for their meticulous vetting of the manuscripts. A special thanks to University Publication Centre (UPENA) of UiTM for giving us this precious opportunity to publish this first issue of volume 5. In this engineering issue we have upgraded the standard of the manuscript reviewing process by inviting more reviewers from our university as well as other universities in Malaysia. We have embarked from previous volume to establish a firm benchmark and create a journal of quality and this current issue remarks a new height of the journal quality. Instead of publishing once in every two years, now *Esteem* publishes two issues annually.

In this issue, we have compiled an array of 13 interesting engineering research and technical based articles for your reading. The first article is entitled "The Response of Tube Splitting on Circular Tubes by Using Various Types of Semi-angles Dies and Slits". The authors, Mohd Rozaiman Aziz and Roslan Ahmad investigated the axial splitting and curling behavior of aluminum circular metal tubes which was compressed axially under static loading using three types of dies with different semi-angles. The authors concluded that the introduction of slit to the specimen is necessary to initiate slitting rather than inversion.

Salina Budin, Aznifa Mahyam Zaharudin, and Sugeng Priyanto presents a model of energy conversion and impact energy generation during collision based on free falling experiment, which is closely resembles direct collision between ball and inner wall of the vial. Simulation results from the proposed impact energy model demonstrated that the impact energy generated during the collision is strongly influenced by the thickness of the work materials and reaches zero at certain value of the work materials thickness, which increases with an increase of falling height.

Salina Alias, Caroline Marajan and Mohamad Azrul Jemain wrote an article that looks at adsorption of zinc from waste water using bladderwort (*Utricularia vulgaris*). In batch adsorption studies, data show that dried bladderwort has considerable potential in the removal of metal ions from aqueous solution. The fourth article written by

Muhammad Khusairi Osman et al. looked at 3D object recognition using affine moment invariants and Multiple Adaptive Network Based Fuzzy Inference System (MANFIS). The experimental results show that Affine Moment Invariants combined with MANFIS network attain the best performance in both recognitions, polyhedral and free-form objects.

The article entitled "Construction Waste Management Methods Used by Contractors in the Northern Region" authored by Siti Hafizan Hassan, Nadira Ahzahar and Mohd Nasrul Nizam Nasri reports an ongoing study on the use of construction waste management methods by contractors and its impact on waste reduction in the Northern Region. In conclusion, the sizing and amount of materials to be ordered to reduce wastage is significant in reducing construction waste generation waste, alleviating the burden associated with its management and disposal. The sixth article by Muhammad Sofian Abdullah et al. examined on the performance of Performance of Palm Oil Fuel Ash (POFA) with lime as stabilizing agent for soil improvement. The authors concluded that POFA can be used to treat the silty soil as well as to reduce the environmental problem.

The seventh article penned by Soffian Noor Mat Saliah, Noorsuhada Md. Nor and Megat Azmi Megat Johari presents the results of an experimental study on the interfacial bond strength (IBS) of polypropylene fiber concrete (PFC). It was found that the interfacial bond strength between concrete and reinforcement bar was not affected by the inclusion of polypropylene fibers. However, concrete containing fibers exhibited no breaking of concrete and no debonding of reinforcement. The article by Juliana Zaabar and Rusnani measures, evaluates and analyzes the network link performance of fiber optic cable using OTDR. The authors suggested that the major loss for these measurements is connector loss. Preventive maintenance will increase the life time of fiber optic. From some of the findings, the PVC dust cap has been identified as a main source of contamination for the SC connector.

The article entitled "Symbolic Programming of Finite Element Equation Solving for Plane Truss Problem" by Syahrul Fithry Senin proposed a plane truss problem to be solved by finite element method using MAPLE 12 software. The numerical solution computed by the author was almost matched with the commercial finite element software solution, LUSAS. The tenth article by Nor Azlan Othman, Nor Salwa Damanhuri and Visakan Kadirkamanathan presents a detail review of fault diagnosis in rotating machinery using pattern recognition technique. The authors proposed a solution based on artificial neural network (ANNs) which is Multi-Layer Perceptron (MLP). The authors concluded that the proposed methods are suitable for rotating machinery on fault detection and diagnosis.

The eleventh article is entitled "RAS Index as a Tool to Predict Sinkhole Failures in Limestone Formation Areas in Malaysia". Damanhuri Jamalludin et al. found that, using the RAS classification method, the prediction of sinkhole occurrences can be easily be made by simply knowing the weekly rainfall especially in areas having limestone as the bedrock. The twelfth by Muhammad Hafeez Osman et al. explores cases regarding the histories of rock slope repair and stabilization of unstable boulder along the road from Bukit Cincin to Genting Highland and along the road from Gap to Fraser Hill. The last article is "Soil Nail and Guniting Works in Pahang". The authors, Damanhuri Jamalludin et al. concluded that if the stability of the embankment needs to be improved, soil nails can be installed and embankment surface can be covered with gunite to prevent erosion.

We do hope that you not only have an enjoyable time reading the articles but would also find them useful. Thank you.

Mohd Aminudin Murad
Chief Editor
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Influence of Fiber Content on the Interfacial Bond Strength of Synthetic Polypropylene Fiber Concrete

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ABSTRACT

This paper presents the results of an experimental study on the interfacial bond strength (IBS) of polypropylene fiber concrete (PFC). The experimental program consisted of testing 24 concrete cylinders (100 mm diameter × 200 mm length) at 7 and 28 days for different inclusion of fiber dosages (4.5, 6.0 and 9.0 kg/m³). The specimens are prepared according to ASTM standards. The test results showed that the IBS of the PFC is inconsistent by increasing the polypropylene fiber dosages compared to plain concrete. At 7 days, the strength efficiency for dosages 4.5, 6.0 and 9.0 kg/m³ is 7.3%, -22.8% and -25.5%, respectively. At 28 days, the strength efficiency for dosages 4.5, 6.0 and 9.0 kg/m³ is -2.6%, -0.6% and -3.6%, respectively. Correlation between interfacial bond strength and dosage levels for synthetic polypropylene fiber produce good relationship up to 50% and below 60% at age of 7 and 28 days, respectively. However, concrete containing fibers exhibited no breaking of concrete and no debonding of reinforcement. Overall the effect of fibers on IBS was minimal and at the same time greater than the minimum specified value.

Keywords: *Polypropylene fiber, interfacial bond strength, debonding*

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Introduction

Improvement in concrete characteristic or performance by adding fibers offer many advantages in the utilization, due to its improved mechanical characteristic and low permeability, as well as due to higher resistance against chemically and mechanically penetrating attacks into the structure of concrete. By such outstanding characteristic one uses this material particularly for the constructions which are extremely influenced by the environmental conditions e.g. offshore constructions and large bridges, or essentially to increase the structural load carrying capacity, while a sufficient durability is ensured to the structure (Aulia, 2002). It is known that uniformly dispersed fibers provide closing stress across cracks and suppress microcracks from opening further and becoming macrocracks. It is also known that the addition of fiber will considerably reduce the crack width (Taylor, 1989; Balaguru, 1994).

In construction industry, steel bars are the most widely used which exposed to aggressive environments accelerate deterioration of concrete. The use of a composite reinforcing bar for concrete as an alternative to traditional steel reinforcing bar has many potential advantages (Abdolkarim & Paul, 2005). Thus interfacial bond strength (IBS) in the determination of mechanical properties of fiber reinforced concrete is often necessitated, since it strongly affects their ultimate performance in applications. Many researchers have studied IBS for many types of materials as described below. In this paper only focused on IBS of synthetic polypropylene fiber since it is less explored by other researchers.

According to Lee et al. (2007), good performance of reinforced concrete requires adequate interfacial bond between the reinforcing material and the concrete due to the load applied must be transferred from the matrix to the reinforcement. Francessa, Edoardo, Manfredi, & Marisa (2006) added that all of these related to material properties as well as bar-concrete interaction. In other perspective by Shortall and Yip (1976) stated that the real interfacial bond strengths of well bonded glass-fibre polyester resin systems to be of the order of 70 MN/m^2. Lee et al. (2007) showed that the interfacial bond strength of the glass fiber reinforced polymer (GFRP) bars increased as the compressive strength of concrete increased. However, the increasing rate of the bond strength of the GFRP bars with respect to the concrete strength was much smaller than that of the steel bars.

A number of techniques have been adopted to evaluate the interfacial bond strength such as tensile test, pull out test and so forth. In this research only pull out test has been carried out. Gray and Johnston (2003) determined the results indicate that the effect of the component of IBS associated with the matrix mortar mix proportions on the properties of the composite is limited, but significant with respect to uniaxial tensile and first crack flexural strength. Huang, He and Zhang (2002) used pull out test, affirmed that the bond strength of steel fiber of 1.5% by volume friction exceeds that of stirrup ratio of 4%.

Generally the best mechanical properties in a composite depend mainly on fiber orientation, but the adhesion between the fiber and the matrix is also important. This is especially true for short fiber reinforced composites. The fibers are loaded through the matrix and for good performance, the load must be transferred effectively to the fiber and a strong fiber or matrix bond is required. Thus, interfacial bond is one of the important mechanical properties to determine the composite materials performance.

In order to evaluate the influence of synthetic polypropylene fiber concrete, amount of fiber in concrete mix is vital to have some idea about the effect to concrete performance. Thus, in this research the main objective is to study the influence of fiber content in different inclusion of fiber dosages on the interfacial bond strength of synthetic polypropylene fiber concrete, in order to measure the interfacial strength between the rebar and a concrete matrix.

Experimental Program

Material

The concrete was made of Ordinary Portland cement, coarse aggregate, fine aggregate (sand), water and polypropylene fiber from different dosages to observe the interfacial bond strength. Typical polypropylene fiber selected in this research is a macro synthetic fiber designed specifically for reinforcement of concrete and other cementitious mixes (Propex Concrete System, 2006). The coarse aggregate was crushed stone with the maximum size of 20 mm, specific gravity of 2.64, water absorption of 0.47% and fineness modulus of 4.07 (Soffian Noor, Megat Azmi, & Noorsuhada, 2008). The fine aggregate used in the concrete mixtures is dry and clean local river sand with specific gravity of 2.5 and fineness modulus of 4.81 (Soffian et al., 2008). In this research, three types inclusion of fiber dosages used are 4.5, 6.0 and 9.0 kg/m^3.

Experimental Method

In this research, the interfacial bond strength tests were carried out for specimen size of 100 mm diameter x 200 mm length at 7 and 28 days. The objective of this test is to determine the bond strength between the steel bar and synthetic polypropylene fiber concrete. Prior to the test specimen mould prepared using UPVC pipe with diameter of 100 mm. UPVC pipe were cut into several pieces with 200 mm specified length. The center of the end cap pipe drilled 14 mm diameter hole and fixed them by 200 mm length UPVC pipe with special pipe glue. The mould was then clamped onto the wood base plate as shown in Figure 1.

The fresh concrete was then put into the mould and a 14 mm diameter by 700 mm length high yield steel then inserted vertically into the concrete at midpoint (axis) as illustrated in Figure 2. Then the specimen was stored at ± 24 hours in the storage room (see Figure 4) and remoulded prior to submerging into curing tank in the specified time.

After 7 and 28 days of moist curing, specimens were taken out from the curing tank. Their surfaces were wiped with dry cloth prior to conducting the test. The specimens were tested for interfacial bond strength using universal testing machine as shown in Figure 3 with 0.07 kN/s pace rate was applied and maintained until the specimen completely fail.

In conducting the bond experiment, both the test and the support bar were pulled out (in tension) simultaneously. Force transferred to the bar in the central portion of the specimen until its failed or split halves longitudinally and the testing machine manually stopped. Precautions

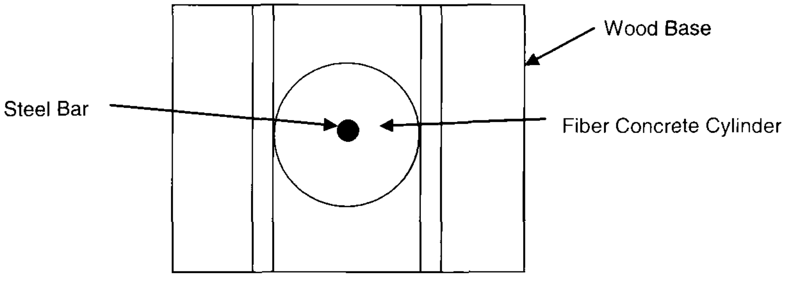

Figure 1: Plan View of the Specimen for Interfacial Bond Strength Test

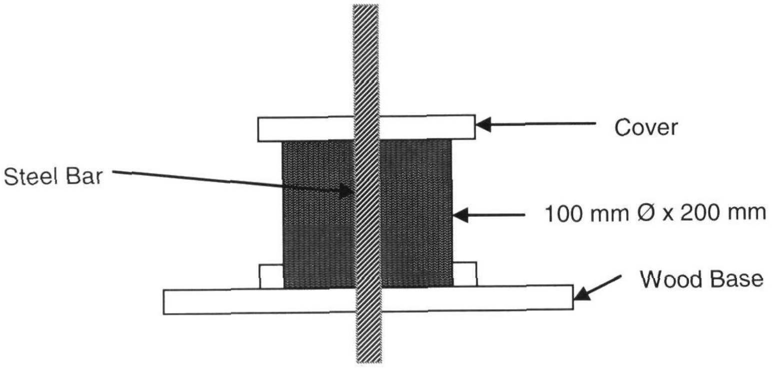

Figure 2: Cross Section of the Specimen for Interfacial Bond Strength Test

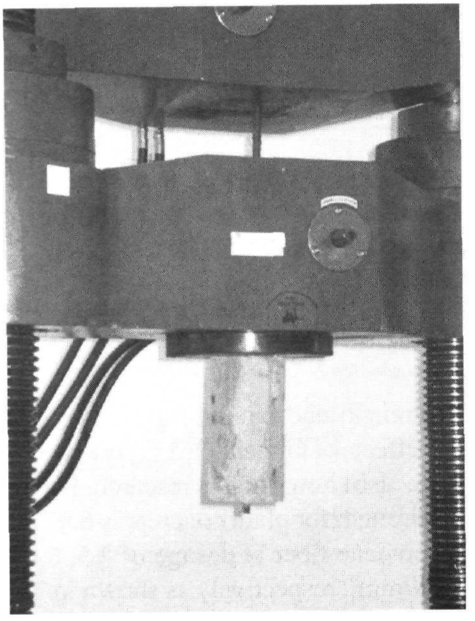

Figure 3: Test Set Up for Interfacial Bond Strength

were needed during the test was carried out in order to prevent undesirable failure modes except bond failure along the test bar. The maximum load applied and crack pattern at the end of test were recorded.

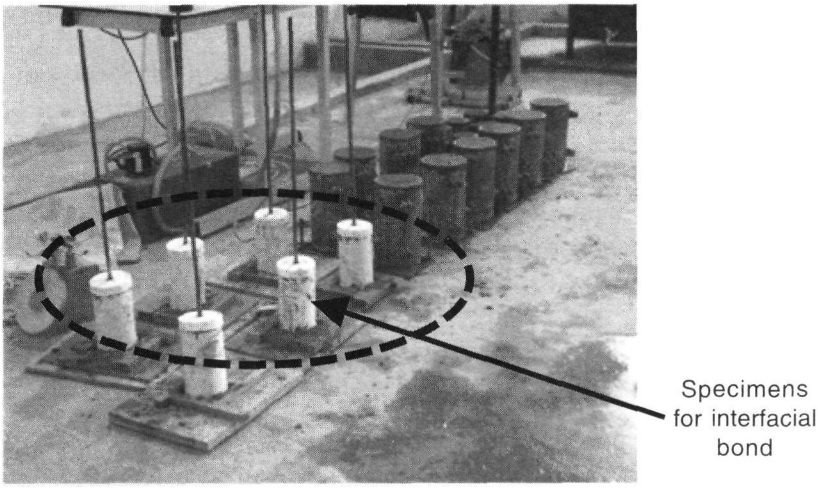

Figure 4: Specimens for Interfacial Bond Strength Test

The average bond strength can be calculated by (Tastani & Pantazopoulou, 2002; Abdolkarim & Paul, 2005):

$$U = P/\pi DL \qquad (1)$$

Where P is the maximum applied load, L (mm) is the anchorage length and D (mm) is the diameter of the test bar.

Results and Discussion

The interfacial bond strength tend to reduce and inconsistent with increasing of fiber dosages. The effects of immersion age period on the bond strength, i.e., 7 and 28 days, are also shown in this research. For example at 7 days, the interfacial bond strength for plain concrete is 6.97 N/mm^2, the results for synthetic polypropylene fiber at dosage of 4.5, 6.0 and 9.0 kg/m^3 is 7.48, 5.38 and 5.19 N/mm^2, respectively as shown in Table 1.

For 28 days, the results were also inconsistent by increasing the fiber dosages. At this stage, the result for plain concrete is greater than fiber concrete. For example, for fiber dosage 4.5, 6.0 and 9.0 kg/m^3 is 7.9, 8.06 and 7.82 N/mm^2, respectively. Thus, produce the negative strength efficiency for fiber concrete, from –0.6% to –3.6%, where strength efficiency is a percentage of strength of polypropylene fiber concrete minus strength of plain concrete divide strength of plain concrete.

Overall, Figure 5 showed that, the hardened concrete at 28 days did not increase the interfacial bond strength for fiber concrete when compared with plain concrete. However, the interfacial bond strength for 28 days are greater than 7 days, indicated that the age of the concretes is important factor in concrete strength.

From results presented in Table 1, the correlation between dosage levels and interfacial bond strength has been studied. Figures 6 and 7 presented the linear analysis of relation between bond strength and inclusion of fiber dosages at 7 and 28 days, respectively. R^2 at 7 days is 0.5266 and at 28 days is 0.5929. It shows medium and approximately good correlation (Cohen, Cohen, West, & Aiken, 2003) between bond

Table 1: Results of Interfacial Bond Strength Test

Summary for synthetic polypropylene fiber concrete						
Dosage (kg/m^3)	Ave. load (kN)	7 days interfacial bond strength (N/mm^2)	Strength efficiency (%)	Ave. load (kN)	28 days interfacial bond strength (N/mm^2)	Strength efficiency (%)
0	52.52	6.97	–	61.12	8.11	–
4.5	56.36	7.48	7.3	59.5	7.9	– 2.6
6	40.56	5.38	– 22.8	60.8	8.06	– 0.6
9	39.17	5.19	– 25.5	58.9	7.82	– 3.6

Strength efficiency = [Strength of PFC – Plain concrete] / Plain concrete x 100%

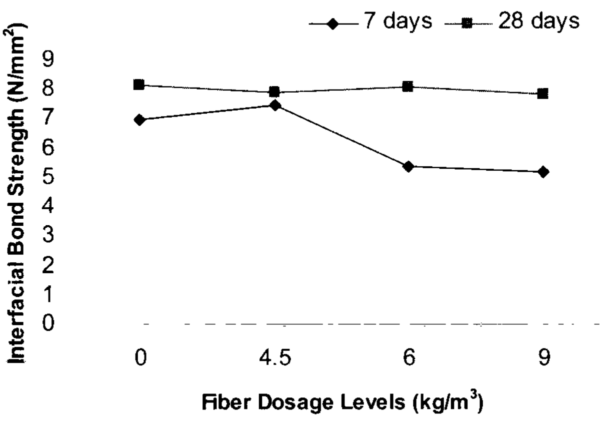

Figure 5: Graph of Interfacial Bond Strength for Synthetic Polypropylene Fiber

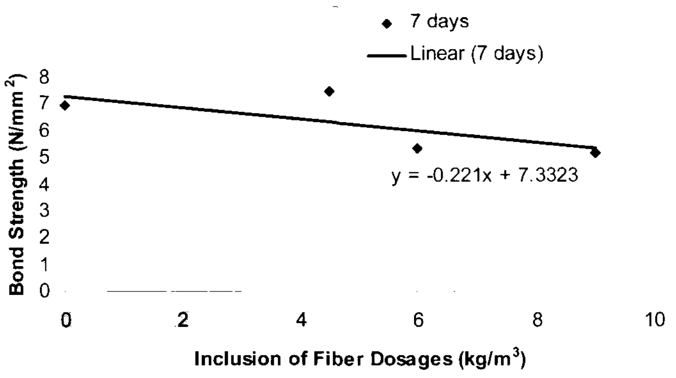

Figure 6: Correlation of Bond Strength and Dosage Levels of Synthetic Polypropylene Fiber at 7 Days

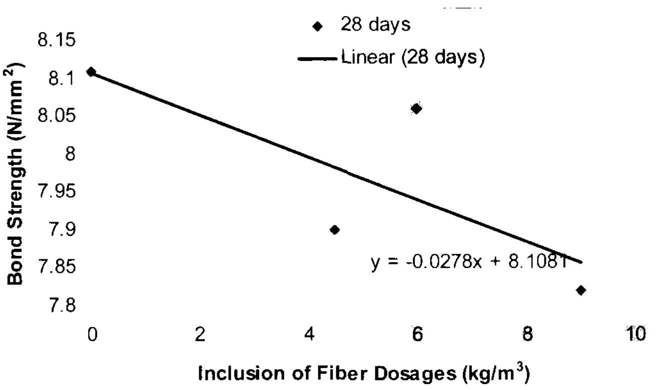

Figure 7: Correlation of Bond Strength and Dosage Levels of Synthetic Polypropylene Fiber at 28 days

strength and dosage level of synthetic polypropylene fiber. It indicated that 50% to 60% of variation on interfacial bond strength is influenced by fiber dosage levels. Equations of linear analysis are presented in Figures 7 and 8.

These specimens were done under pace control rate of 0.07 kN/s aiming to capture the descending branch of the bond. The crack pattern of tested samples was investigated using naked eyes; some representatives from this research are shown in Figures 8 and 9. Figure 8 showed the crack pattern for plain concrete; where the concrete is

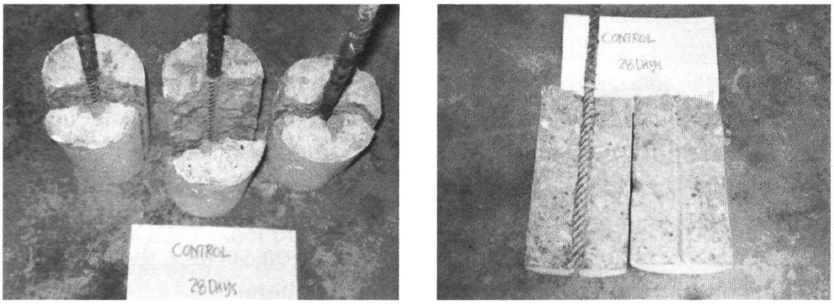

Figure 8: Mode of Failure for Plain Concrete

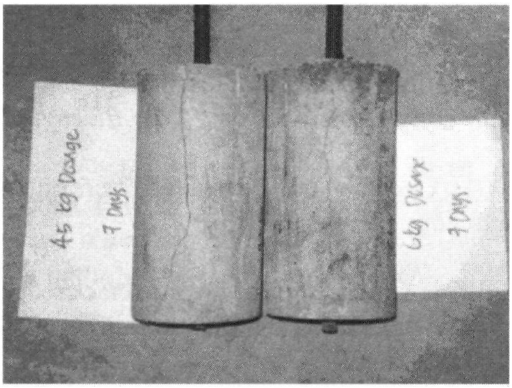

Figure 9: Mode of Failure for Polypropylene Fibers Concrete

broken into several portions and the bar reinforcement was debonded completely from the concrete. Meanwhile, Figure 9 presented the crack pattern for polypropylene fiber concrete, where the small line cracks appeared on the surface and the reinforcement bar was still bonded with the concrete, due to ability of fiber to resist and reduce cracking of concrete (Tastani & Pantazopoulou, 2002). It is because the matrix at the surface of the bar appeared to have been abraded in all cases.

Conclusion

Interfacial bond strength between concrete and reinforcement bar was not affected by the inclusion of polypropylene fibers. However, concrete containing fibers exhibited no breaking of concrete and no debonding of reinforcement. Overall the effect of fibers on interfacial bond strength was minimal and at the same time greater than the minimum specified value. Correlation between interfacial bond strength and dosage levels for synthetic polypropylene fiber produce good relationship up to 50% and below 6% at age of 7 and 28 days, respectively. The crack pattern for plain concrete is generally splitting into two halves. For fibers concrete, the specimen cracked with small line appear on surface diameter and did not split into two parts due to bonding of fibers.

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