RESEARCH ARTICLE OPEN ACCESS

Serviceability behavior of Reinforcement Concrete beams with polypropylene and steel fibers

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Abstract
Serviceability Limit States (SLS) may lead to the design of concrete elements internally reinforced with Fiber Reinforced Polymer (FRP).In many types of concrete structure loss the serviceability due to wide cracks, number of cracks or large deflection is not uncommon behaviour in concrete structures or concrete beams.The flexural ductility affects the serviceability deflection of RC beams once flexural cracking take place.Imprvement will be focused on the use of polypropilene fibres , which is the subject of thispaper.
The performance of concrete with fibers is judged by the flexural toughness obtained by load-deflection curves. The flexural toughness of concrete is depend on different types of fibersin use.Its tougness will be reperesent in the behaviour of RC memebres at failure. Sometimes, it is difficult to use the flexural toughness to judge the behavior of concrete structures under service load. The result of cracking on concrete beam due to the applied load and the method of loading to monitor and check the performance of concrete with different types of fiber arediscussed in this paper.
The reductionin the dimension of cracks and the effect of energy disipations of polypropilene fibres will be the main aim of this research work.
Keywords: RC beams, polypropylene fibers, strengthening, flexural strength, deflection, ductility, energy

I. INTRODUCTION

Behavior of the Concrete such a brittle material with low tensile strength and low strain capacity it's the one of the main aim to improve. Its mechanical behavior is critically influenced by crack propagation. Problems related to concrete brittleness and poor resistance to cracking can be addressed by reinforcing plain concrete with randomly distributed fibers. Moreover, addition of fibers reduces immediate deflection, long-term deflection and crack width of concrete beam.

The design objective for a concrete structure is that it should satisfy the needs for which it was contrived. During the design, the structural designer must ensure that it is both safe and serviceable, so that the chances of it failing during its design lifetime are sufficiently small. The two primary structural design objectives are therefore *strength* and *serviceability*.

Today the design codes for structures have adopted the *limit states method* of design, whereby a structure must be designed to simultaneously satisfy a number of different *limit states* or design requirements, including adequate strength and serviceability.

In this paper, is presented the effects of different types of fiber for concrete with own characteristics such as, steel fibers has high dynamical performance, but it is rust .On the other hand, polypropylene fibers is elastic and flexible, it does not pierce the hands or the feet of the workers under construction. But concrete with polypropylene fibers cannot be expected as high toughness at failure as concrete with steel fibers. Almost it is the same effect on the deflection and cracking state of reinforced concrete beams and is discussions on direct relations with the serviceability.

II. SERVICEABILITY LIMIT STATE

1.1. Limit State on Crack Width

In a general design of RC structures, the tensile stress of concrete is neglected and the reinforcement is provided to resist all tensile forces arising in a section. Normally cracking of concrete does not directly lead to the failure of RC structures. However, in the case of design which has to consider the tensile resistance of concrete such as plain concrete structures, the failure of such structures is highly related to the cracking of concrete. Even in the case of RC structures, when they are subjected to relatively low shear forces, the tensile resistance of concrete is expected implicitly and hence diagonal cracking becomes serious. In addition, in the anchorage zone of a deformed bar, since the tensile resistance of concrete is taken into account, it is necessary to pay attention on cracking along the bar.

In the case of RC structures subjected to flexure under the service loads, cracks occur in the flexural tension zone of the section. The excessive crack width leads to unfavorable consequences as follows:

- Due to the penetration of water and air through the crack, the corrosion ofreinforcement inside the concrete occurs
- In the design of structures with special attention on air as well as water tightness,the function of the structure will be lost if a crack having excessive width occurs
- In the aesthetic view point, excessive crack is undesirable

1.2. Prediction of Flexural Crack Width

When the flexural moment is applied to RC beams, a flexural crack due to flexural tensile stress occurs at the extreme tension fiber. Then, as the moment is increased, the number of cracks increases and the *crack spacing* gets smaller. This will cause the tensile stress in concrete between the adjacent cracks. After the initiation of number of flexural cracks, new cracks are hardly formed because of a relatively short development length for bond stress. Hence, *the stable state of cracking* is obtained. At this stage, cracked portion around the tensile reinforcement in a flexural member can be considered to be equivalent to a concrete member having a single reinforcement subjected to pull-out force at both ends

III. EXPERIMENTAL PROGRAM

The proportioning of the constituent materials in concrete mixtures for testing is summarized in Table 1.

Table 1-Mix Proportions of Concrete

Mix Design	weight per unit volume (kg/m3)				
	C	A	W	Admixture	Fibers
"1"	340	1865	160	3.5	/
	C	A	W	Sika 10-20	PP
"2"	340	1865	160	3.5	0.50%
	C	A	W	Sika 10-20	SF
"3"	340	1865	160	3.5	0.50%

Superplasticizer admixture is product of “Sika” in amount of 1 % of the total cement.
All concrete mixtures were prepared with ordinary Portland cement CEM II 42.5. The fine aggregate used in concrete was natural river sand and the coarse aggregate was crushed sand stone with 16 mm maximum size Two types of fiber are used: polypropylene fibers and steel fibers 0.5 % by volume. The fibers were replaced with a part of aggregate. The properties of fibers are presented in Table 2.

Table 2-Properties of fibers

Fibers	Type	Production	length/diameter (mm)	density (gr/cm3)	tensile strength (N/mm2)
PP	MapeiFiber NS12/NS18	Mapei/ITALY	12 to 18	0.91	400-500
Steel	Straight-Hooked-end	Inomix/GREECE	20-60/0.75-1	steel	1100

In the test for flexural static loading, center points loading was applied to the specimen. Deflection measurements were obtained using a dial gage accurate to 0.01 mm. Measurements were recorded at midspan. Cracks width was measured at the bottom of specimen using a microscope reading to 0.02 mm. The RC Beam tested in flexural static loading is shown in Figure 1.

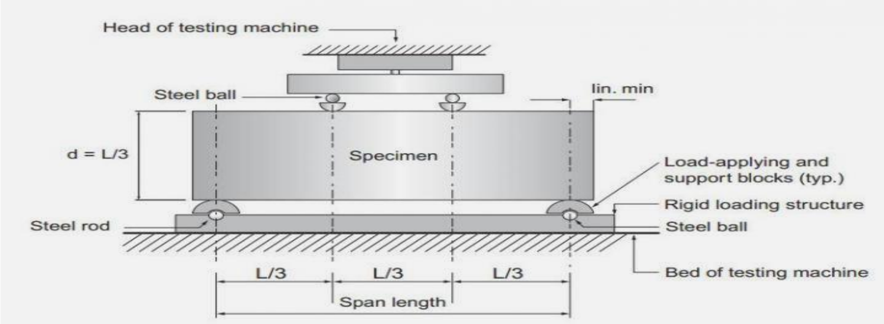

Fig. 1.Testing of the specimens

IV. EXPERIMENTAL RESULTS AND DISCUSSION

3.1. Calculations for the Moment of Rupture

Examinations in all sets is based on the prism model with dimensions 15x15x60 cm and calculations are presented in Table 3, according to the ASTM, using the method of “third point load”, presented in fig 2 and fig 3,

Table 3- calculations the Modulus of Rupture and Cracking Moment

Calculations	**Set 1**	**Set 2**	**Set3**
Modulus of rupture: **MOR(R)=P*L/b*h² (N/mm2)**	**3.39**	**3.82**	**4.00**
Cracking Moment: **Mcr=b*h²*MOR /6 (KN*mm)**	**1909.5**	**2149.5**	**2250**

The calculations is done for three sets: Plain Concrete;(Set 1) Plain Concrete +0.5 % PP fibers (Set 2) and Plain Concrete +0.5 % Steel Fibers(set 3).

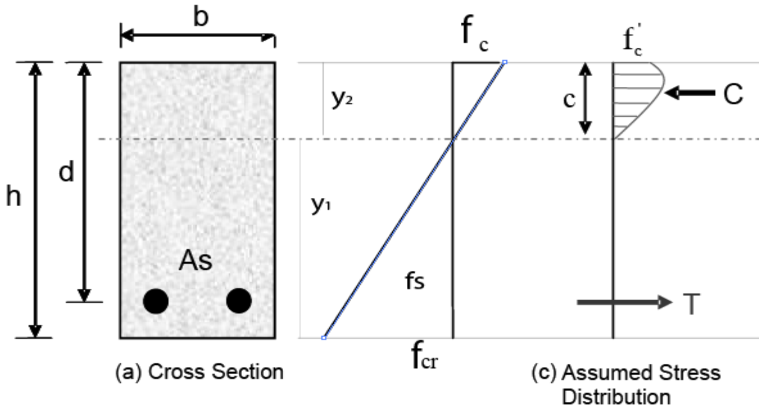

Fig.2- The internal forces in cross section of specimens

3.2. Calculations of Ultimate Moment

Depend of sets and the properties of all materials the Ultimate Moment is calculated in analytical form based on the equations (1), using and calculations all the necessary geometrical parameters for specimens, presented in Fig.3. Analytical calculations is based on the Eq. 1.

$$M_u = T_s \times z_1 + (T_{f1} + T_{f2}) \times z_2 \quad (1)$$

Analyzing the Ultimate Moments for all three sets is presented in table 4.

Table 4- Results of UM for three sets

	Set 1	Set 2	Set 3
Ultimate moment (N*mm)	**3614378**	**5147233**	**5544421**

3.3. Relations between the Loading and Cracking Moment

Comparing the different sets is presented in depends the age of concrete, and in this work its result with the focused target will be the age of 56 days, because the improvement is visible. The results are presented for 28 and 56 days age, in fig 3 and fig.4.

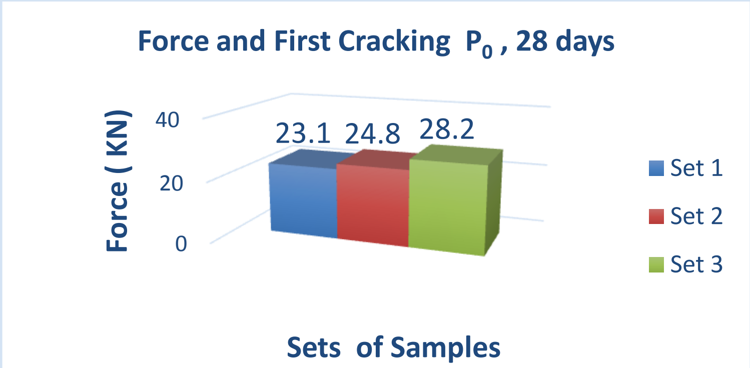

Fig3. First cracks on 28 days

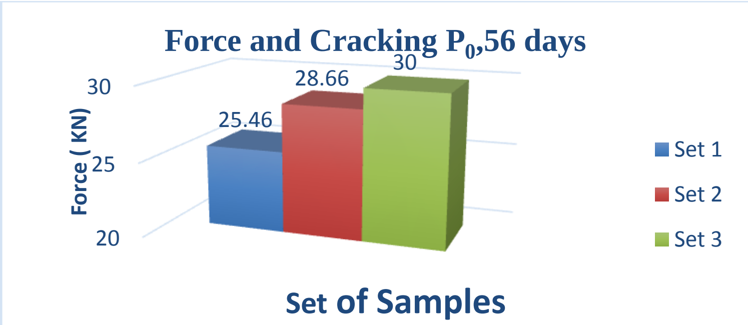

Fig 4. First cracks on 56 days

3.4.Relations between the Cracking Moment and Ultimate Moment

Behavior the exanimated samples and serviceability on the time process of loading will be presented with ratio between the Cracking Moment and Ultimate Moment in different time periods, 28 and 56 days. The effectivity is presenting in comparing the Set 1 (with 0.5 % PP) and Set 2 (0.5 % SF) in fig.5.and fig.6.

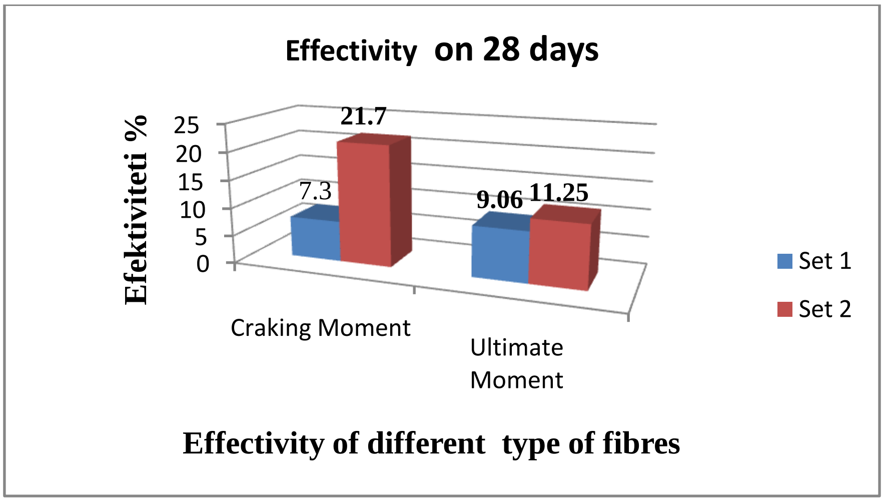

Fig.5 Effectivity on 28 days age

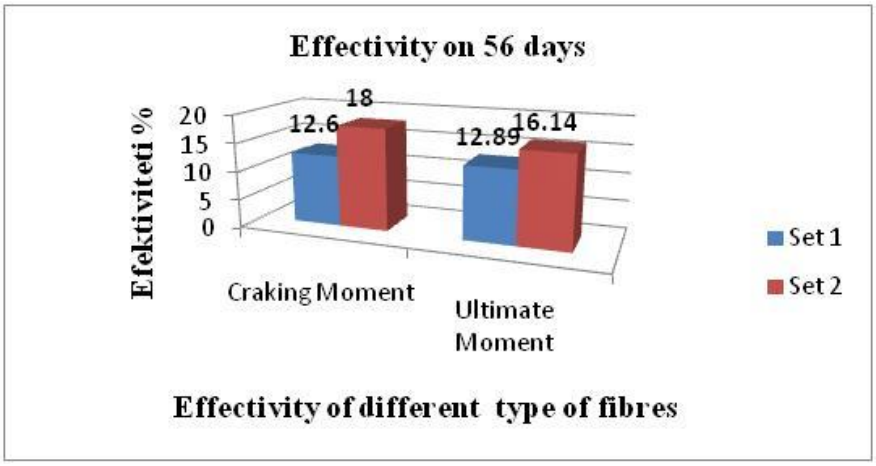

Fig.6Effectivity on 56 days age

V. Deflections and Serviceability in 28 and 56 days

The experimental moment-deflection values at midspan are shown in Fig. .in both cases but for different age. The deflection behavior is same with the decreasing the deflections in 56 days according to the cracking The reinforcement ratio using the different types of fibres results with different measurement of deflections, also in different ages, presented in fig.7and fig.8

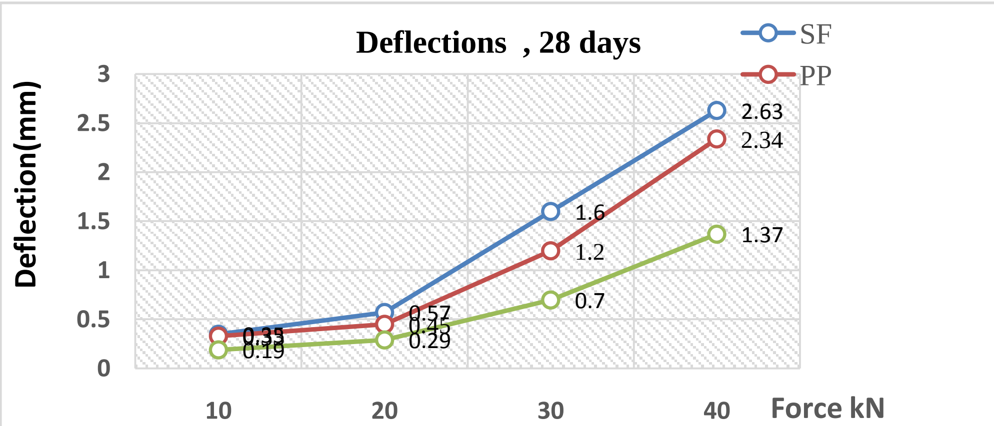

Fig. 7- deflections of different sets on the 28 days

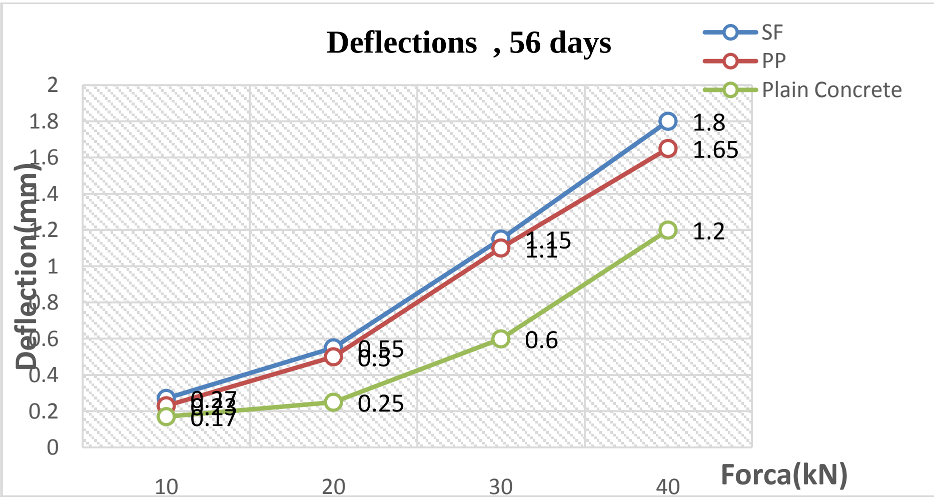

Fig. 8- deflections of different sets on the 56 days

The mid-span cracks, mode failure and deflections are the main factors indicated in servicibility of the examinated samples.

VI. Conclusions

The load deflection curves indicated the advantage of fibrous concrete versus control concrete in obtaining higher toughness. Also, the development of crack width of specimen without fibers was quite different than those with steel fibers or polypropylene fibers.

- By comparison between steel fibers and polypropylene fibers in performance of flexural toughness and crack propagation, it was found that, steel fibers have good performance in flexural toughness than that of polypropylene fibers, especially in cracks mesauremts
- On the other hand, steel fibers and polypropylene fibers have the same performance in crack propagation with the advantage of polypropylene fibers.
- The Young's modulus of polypropylene fibers is about one tenth of steel fibers, it was noticed that the number of cracks and crack width was not increased so much when even polypropylene fibers is used.
- In spite of the flexural toughness can describe the toughness of concrete structural members with fibers at failure, it is not easy to use it in order to explain the propagation of cracking under service load.
- It is necessary to express the sustaining ability of load after cracking by an adequate estimating method. In addition, the reliable and easy method to judge the performance of concrete with fibers is necessary that everybody can choose the adequate fibers in order to improve the serviceabilityofconcretestructures.

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