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Full Length Research Paper

Combined Effect of glass fiber and polypropylene fiber on mechanical property of self-compacting concrete

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Self-compacting concrete is state-of-the-art technology in all over the world in construction field. This concrete which has high performance can be used for casting heavily reinforced sections, places where there can be no access to vibrators for compaction and in complex shapes of formwork which may otherwise be impossible to cast, giving a far superior surface than conventional concrete. In another aspect, using types of fibers can redeem mechanical and dynamical characteristic of concrete as well as reducing cracking in concrete. In this study, we are going to scrutinize both combined and entity effect of polypropylene and glass on mechanical properties of concrete and Rheological Characterization of Self-Compacting Concrete. For this case, we prepared 10 specimen including (A) polypropylene fiber with Volume fraction of 0.1, 0.2, 0.3 and Glass with volume friction of 0.1, 0.2, 0.3 and (B) combined polypropylene fiber and glass. Inspection of these experiments has shown that combined polypropylene fiber and glass can enhance tensile and bending strength, plus it dramatically increase toughness of concrete.

Keywords: Self-Consolidating Concrete, fibers, mechanical properties, polypropylene

INTRODUCTION

Self-consolidation concrete was introduced for reaching to good quality of concrete in 1811, and initial study was administered on performance of self-consolidation concrete by Ozawa (1818) and Okamura (1883) in Tokyo University (De Schutter et al., 2008) (Ozawa et al., 1996) (Okamura and Ozawa, 1994). Considering one theory , Self-consolidating concrete or self-compacting concrete (SCC) is characterized by a low yield stress, high deformability, and moderate viscosity necessary to ensure uniform suspension of solid particles during transportation, placement (without external compaction), and thereafter until the concrete sets (Ali Hussein Hameed, 2012). Here are several advantages of utilizing this material; Building faster and reducing human resource for the sake of being self-compact (SCC), optimizing durability owing to reducing permeability, make our design easier. Although it has some disadvantages which one of them is low tensile strength, due to the fact it has low plasticity and high brittleness. For solving this flaw, concrete is used with bars as reinforcement concrete. Even though using bars are not always either practical or incurring much more money; for instance water channel shell, furnishing, airports and so on. For

Table1. chemical properties of cement

Chemical composition		Chemical composition	
SiO_2	21.25	CaO	64.07
Al_2O_3	4.95	MgO	1.20
Fe_2O_3	3.19	SO3	2.04
K2O	0.63	Na2O	0.38

Table2: physical and mechanical properties of fibers

Aspect ratio	Diameter (mm)	Length (mm)	Tensile strength kg/cm^2	Young's modulus kg/cm^2*10^5	Specific gravity gr/cm^3	shape	fiber
120	0.1	12	4500	0.5	0.91	smooth	polypropylene
600	0.02	12	14000	7.2	2.5	smooth	glass

Table3: concrete mix design

Mix NO.	Series	Fiber vf (%)		Gravel	Sand	Lime stone powder	Cement	Water	SP
1	A	*		722	826	288.7	413.2	163	7.7
2		P.P	0.1	722	826	288.7	413.2	163	7.7
3			0.2	722	826	288.7	413.2	163	7.7
4			0.3	722	826	288.7	413.2	163	7.7
5		Glass	0.1	722	826	288.7	413.2	163	7.7
6			0.2	722	826	288.7	413.2	163	7.7
7			0.3	722	826	288.7	413.2	163	7.7
8	B	P.P+Glass	0.1P.P+0.2 Glass	722	826	288.7	413.2	163	7.7
9			0.15P.P+0.15 Glass	722	826	288.7	413.2	163	7.7
10			0.2P.P+0.1 Glass	722	826	288.7	413.2	163	7.7

this case, since several decades ago, fibers were used in concrete which spread constantly.

Destruction and deterioration of concrete depends on creating cracks and tiny cracks due to loads or related environmental impacts. Thermal and moisture change in cement paste cause tiny cracks. With increasing loads and another related environmental impact, tiny cracks spread in concrete body (Parviz Soroushian, 1986).

Utilizing divergent fibers in concrete and producing fiber-reinforced concrete (FRC) is effective pace to preclude cracks and tiny cracks from spreading and ameliorate tensile strength of concrete. Prominent properties of concrete are absorbing energy, flexibility, resistance against impact, due the fact this concrete plays pivotal role in developing technology and it is known as unprecedented and economical material (Singh et al., 2012).

MATERIALS

Cement

We used Portland cement type 2 which its properties is

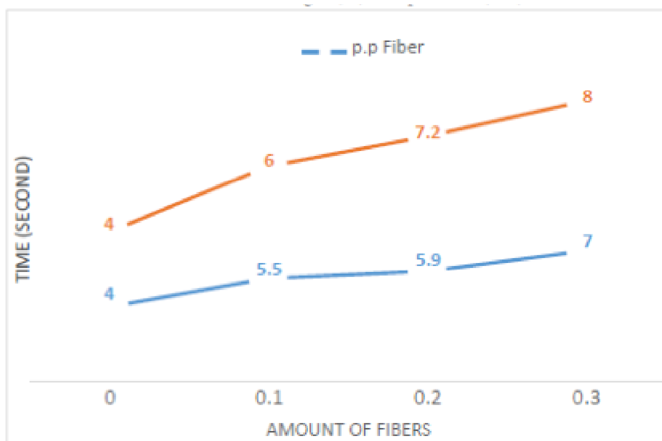


Figure (1a). slump flow test(T50)

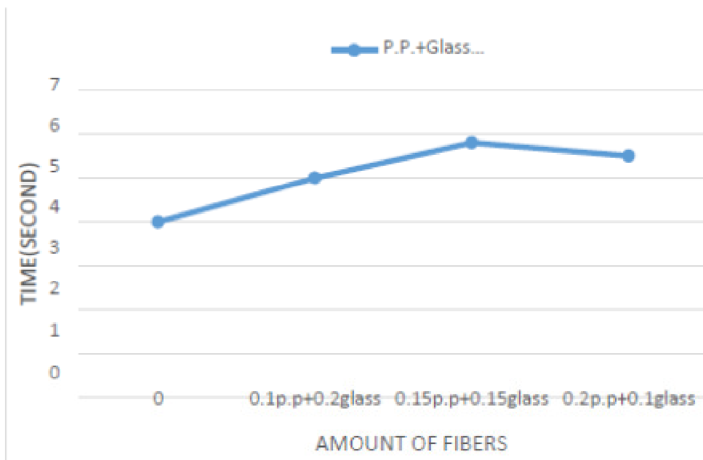


Figure (1b): slump flow test (T50) on combined polypropylene and glass fiber

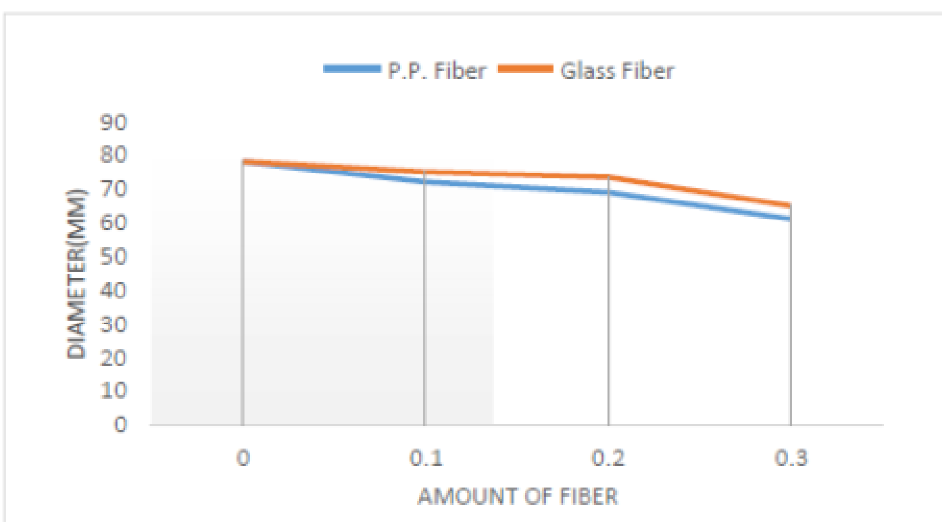


Figure 2. slump test on combined polypropylene and glass fiber

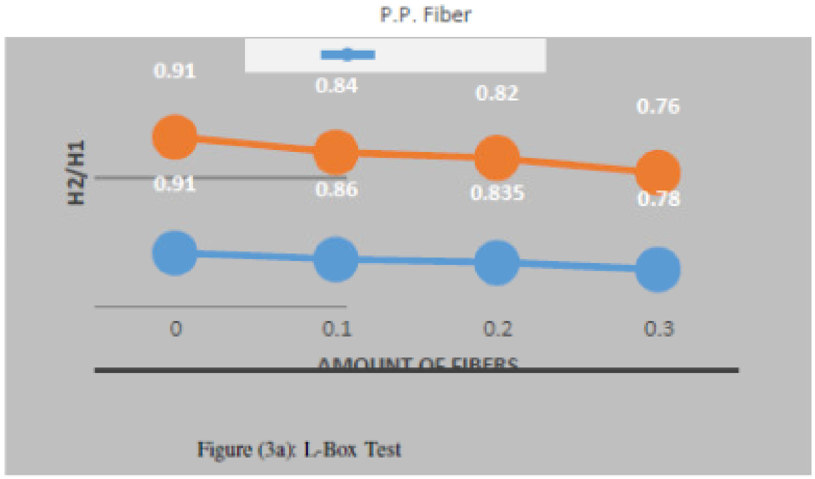


Figure (3a). L-Box Test

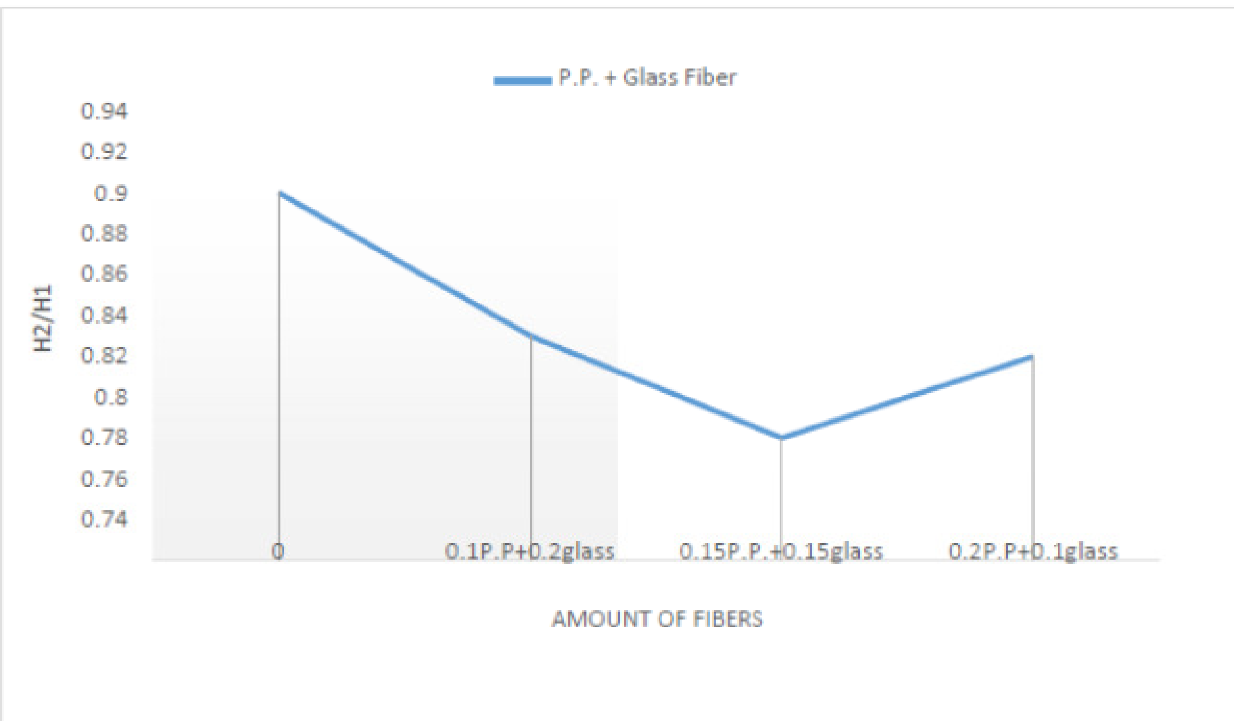


Figure (3b). L-BOX on combined polypropylene and glass fibers

shown in following. Table (1)

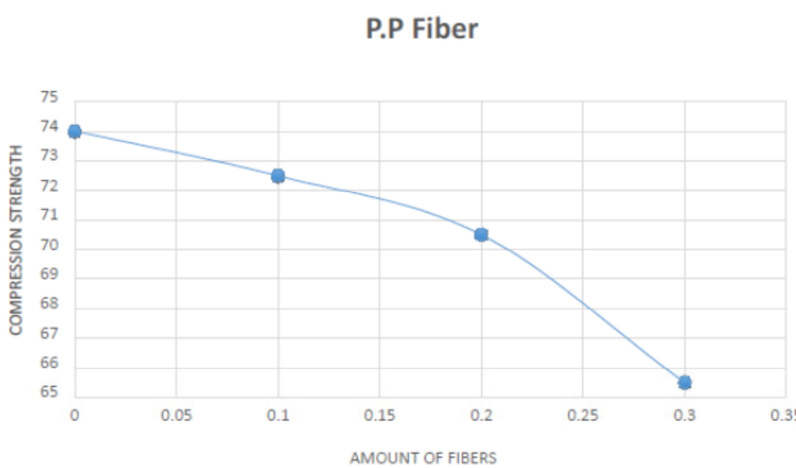
Superplasticizer

for this study , we used GLENIUM_110P which is A high performance concrete (Abbasian et al., 2010) superplasticizer based on modified polycarboxylic ether, GLENIUM 110 P is differentiated from conventional superplasticizers in that it is based on a unique carboxylic ether polymer with long lateral chains. This greatly improves cement dispersion. At the start of the mixing process the same electrostatic dispersion occurs as described previously but the presence of the lateral chains, linked to the polymer backbone, generate a steric hindrance which stabilizes the cement particles capacity to separate and disperse. This mechanism provides flow able concrete with greatly reduced water demand.

Universal device

Table4: results of compression strength of 28 days concrete

Mix NO.	Series	Fiber vf (%)		Compressive Strength (MPa)
1	A	*		74.4
2		P.P	0.1	72.5
3			0.2	70.7
4			0.3	65.8
5		Glass	0.1	73.8
6			0.2	72.3
7			0.3	69.6
8	B	P.P+Glass	0.1P.P+0.2 Glass	73
9			0.15P.P+0.15 Glass	72.5
10			0.2P.P+0.1 Glass	70.4



Figure(4a) : compression strength of polypropelene

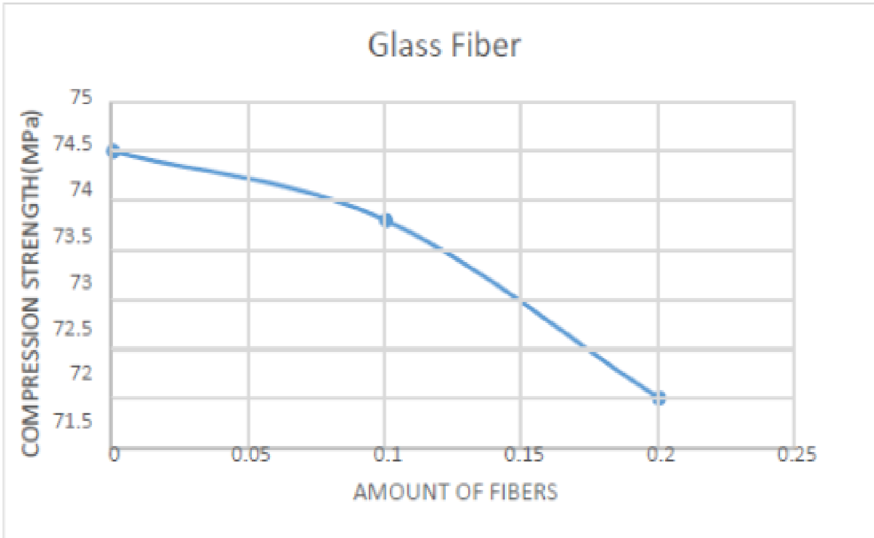
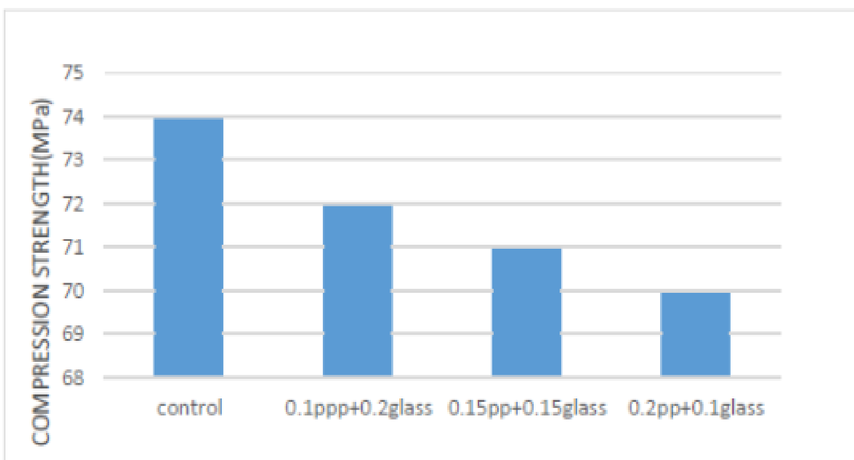
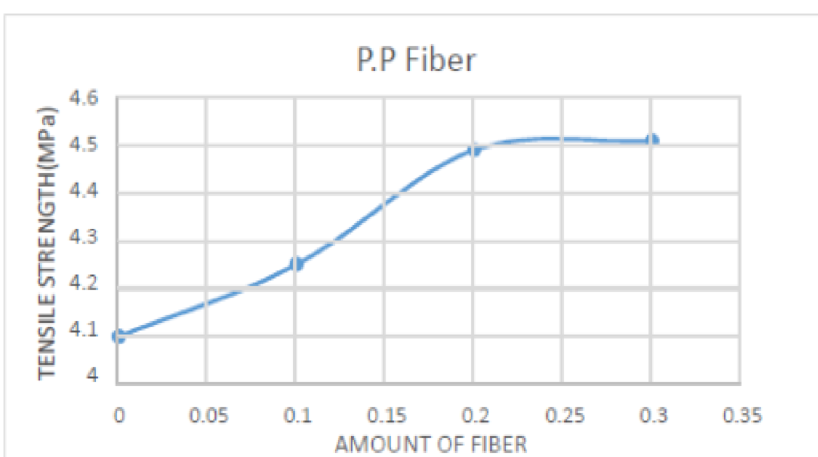


Figure (4b): compression strength of glass fiber



Figure(4c): compression strength containing combined polypropylene and glass fiber



Figure(5a) : tensile strength of polypropelene

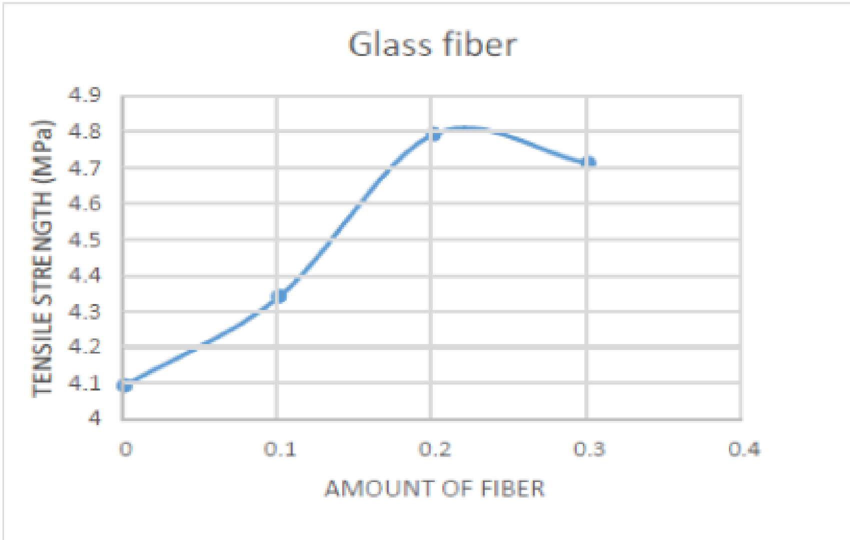
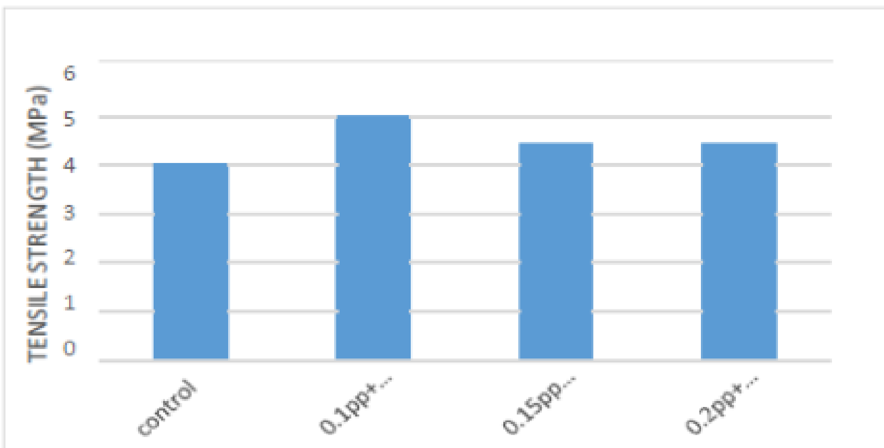


Figure (5b): tensile strength of glass fiber



Figure(5c): tensile strength containing combined polypropylene and glass fiber

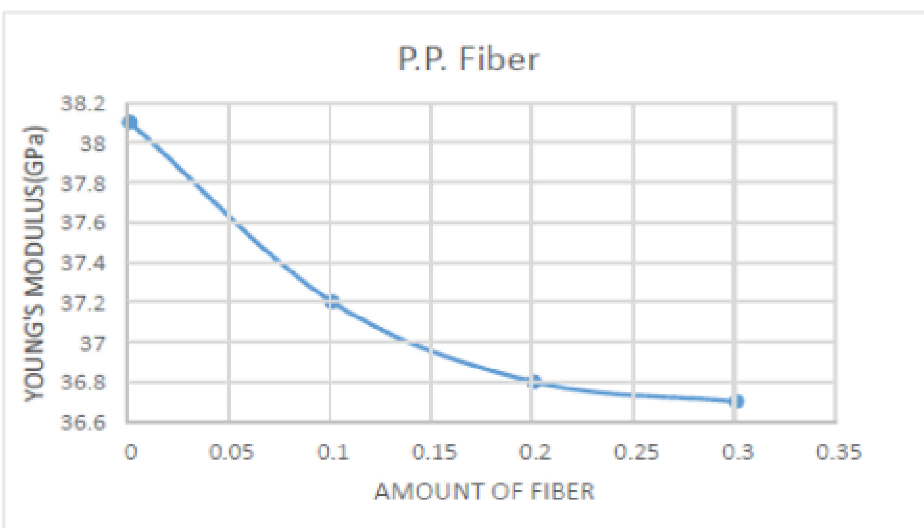


figure (6a) : young's modulus of specimen containing polypropelene

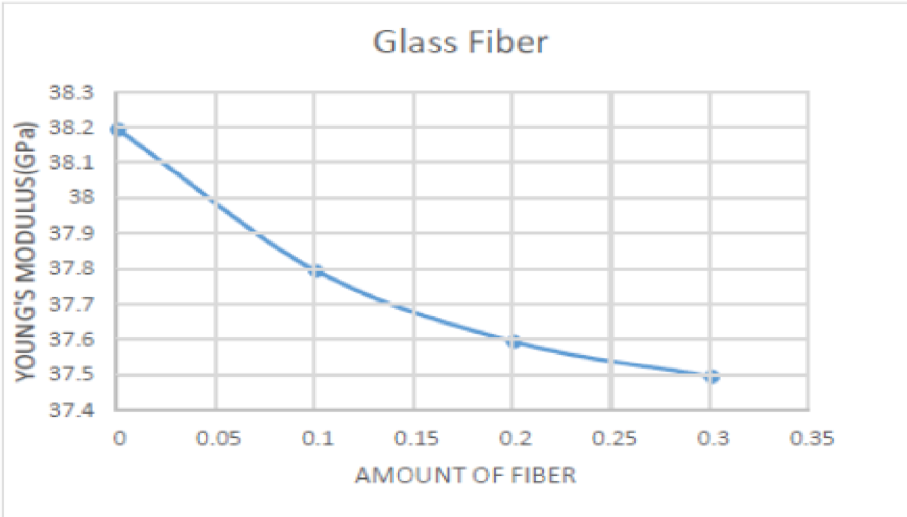
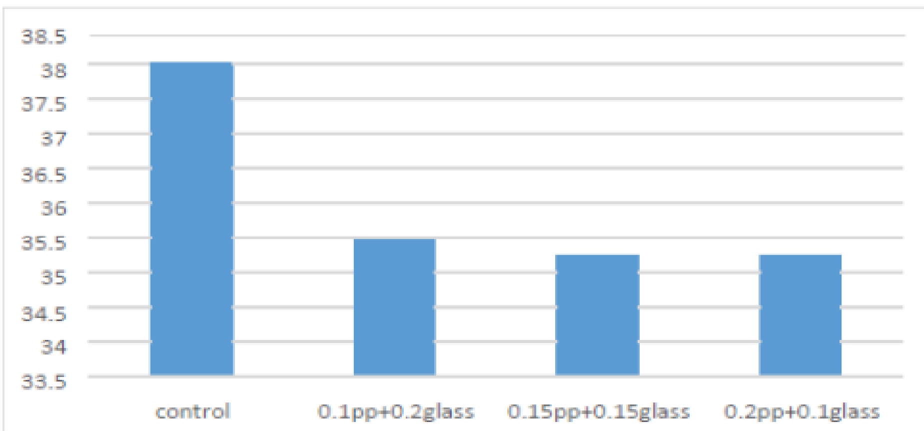


figure (6b) : young's modulus of specimen containing glass



Figure(6c): Young's modulus combined polypropylene and glass fiber

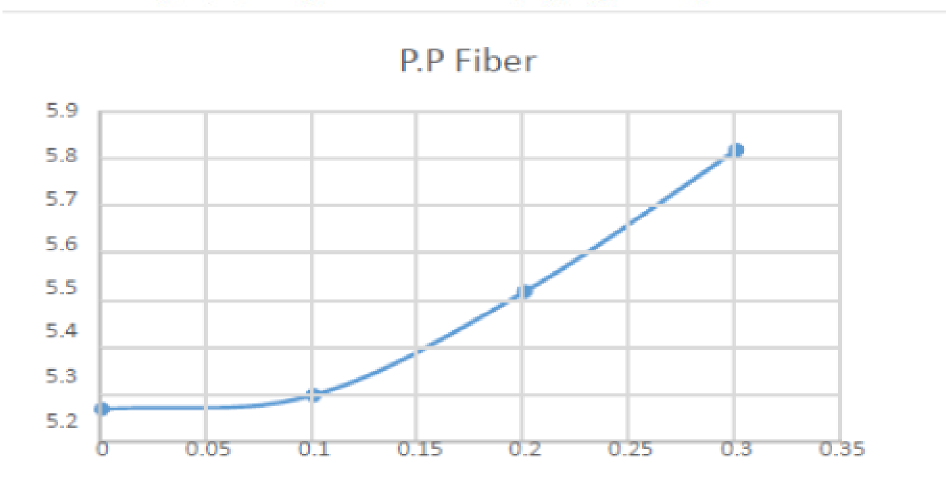


Figure (7a) : bending strength of specimen containing polypropelene

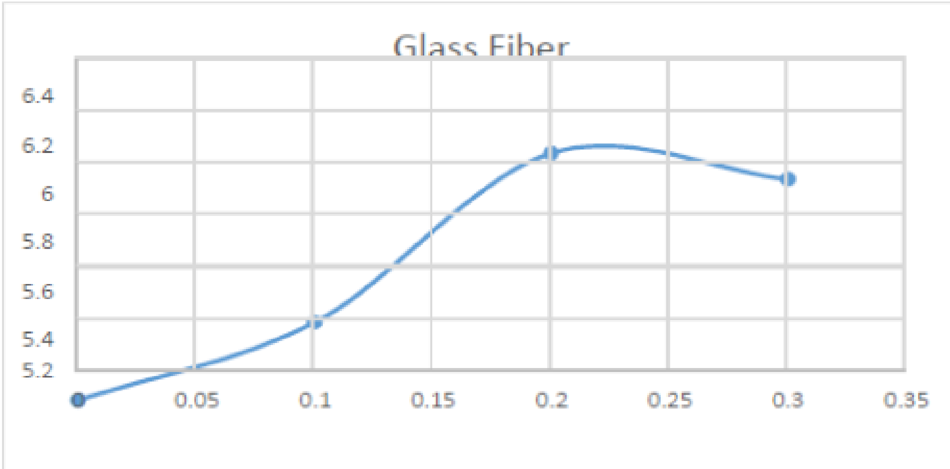
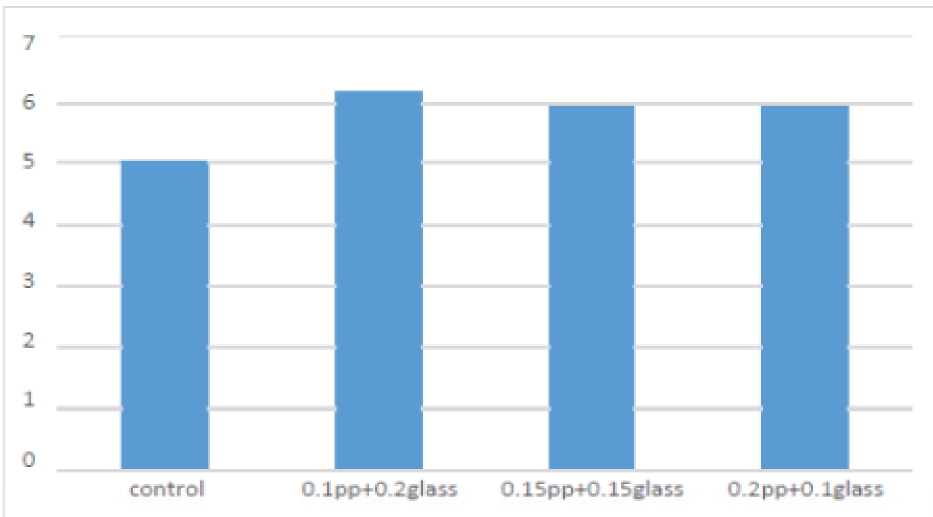


figure (7b) : bending strength of specimen containing glass



Figure(7c): bending strength combined polypropylene and glass fiber

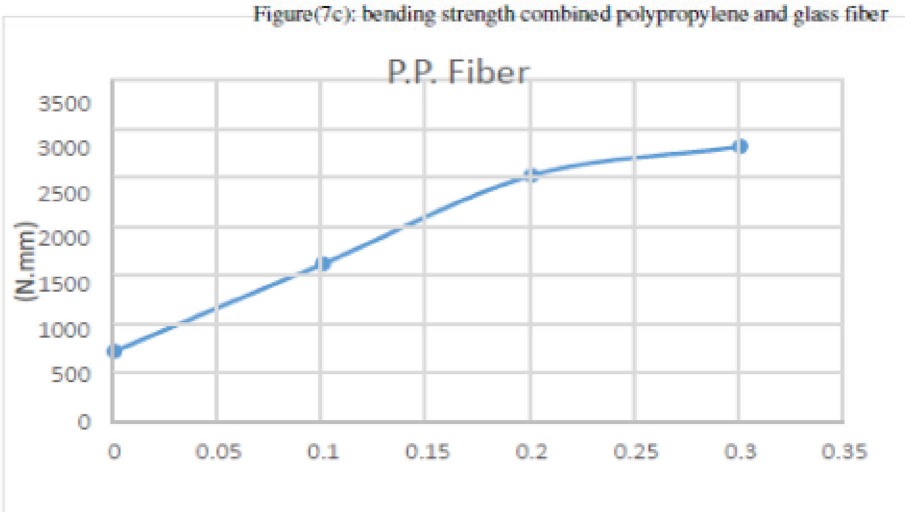


Figure (8a) toughness of specimen containing polypropelene

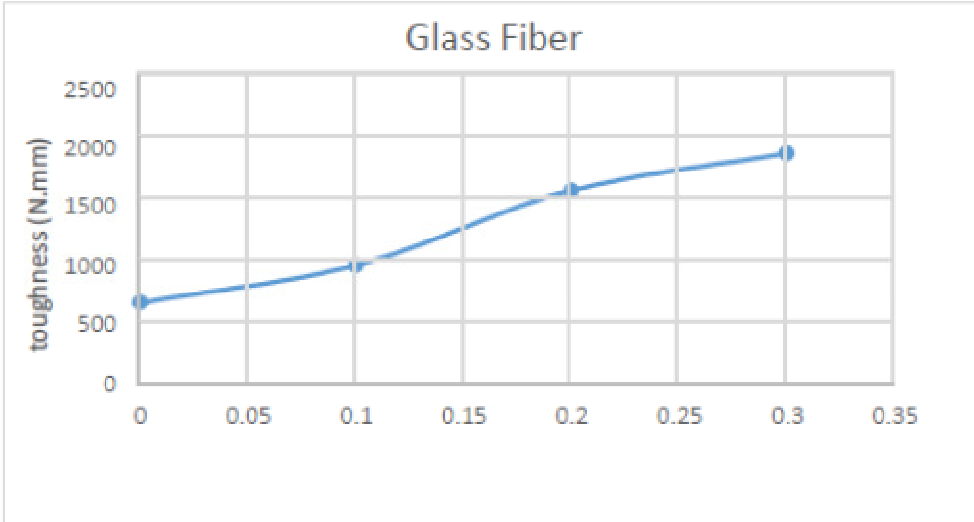
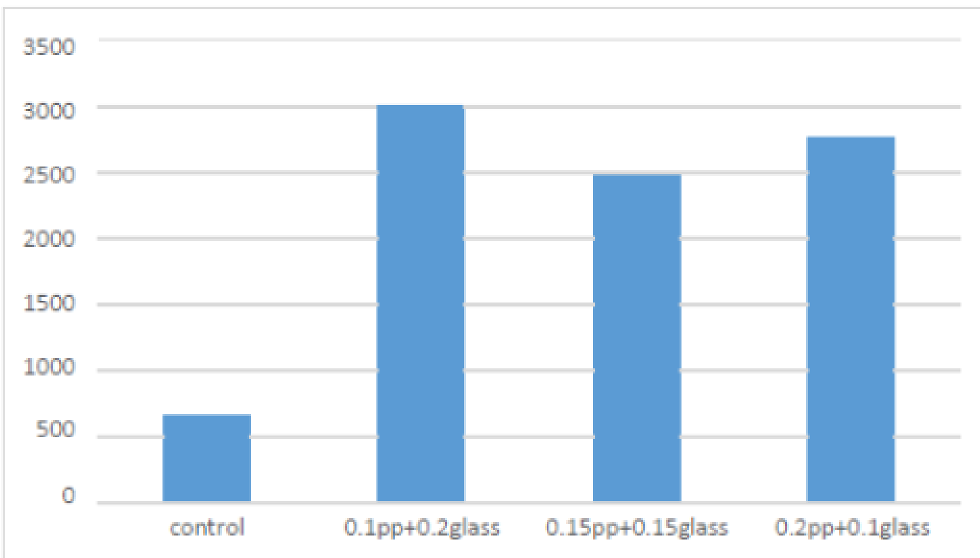


figure (8b) : toughness of specimen containing glass



Figure(8c): toughness of combined polypropylene and glass fiber

Fibers

We used polypropylene and glass fibers which their properties are mentioned in following. Table (2)

Aggregates

Maximum size of gravel was 12.5 mm which has grading diagram in the domain of ASTM standards, in addition, sand were sieved with mesh no 4.75 and we used rock flour with 2.6 gr/cm3 of specific gravity plus with density 2.5 as filler. Fillers such as rock powder is able to fill a void in concrete which leads to decrease porosity of concrete.

Mix design

We followed the instruction of ACI 237R-07 mix design to attain self-consolidating concrete.
Considering prior reports, we expected that the more we use fibers the less performance self-compact concrete will be. [ACI 544.4R] therefore, in mix design for self-compact concrete we attempted that the concrete without fibers

have a high performance regarding [ACI 237R-07] so that after adding fibers it would have good quality in performance analysis.

10 specimen of mix design which includes A and B, (A) polypropylene fiber with Volume fraction of 0.1, 0.2,

0.3 and Glass with volume friction of 0.1, 0.2, 0.3 and (B) combined polypropylene fiber and glass. Moreover, for all these mix designs, we considered all components constant apart from the type and amount of fiber. Table (3). Ratio of water to cement (W/C) is 0.39, and we determine number 1 design which is without fibers as a control plan, VF in table is fiber volume fraction which is ratio of fiber volume to concrete volume. Different amount of polypropylene fibers based on manual and retaining performance specified 0.9, 1.4, 1.8 kg/m^3, and glass fibers 3.75, 5, 7.5 kg/m^3.

Curing and preservation

After completing our mix, those specimens were kept in mold in laboratory condition for 24 hours, then they were kept in water pool in 22-25 centigrade. Each mix designs had 9 cubicle specimens (10*10*10) cm, 6 cylinders (30*15) cm, 3 beam (50*10*10) cm and 1 cylinder (20*10) cm.

Physical properties (Rheology) of fresh SCC

In this study, we used mix design which in spite of using fibers in concrete , it has property of self-compact concrete, in this case, to analyze the performance of self-compact fiber concrete, we applied the standards parameter for self-compact concrete. We used L-BOX experiment for analyzing stability of SCC against detachment and we applied slump test for analyzing deformation or concrete flow. Slump test for self- compact concrete is akin to ordinary concrete but with one difference that after concrete pervades on the table, we have to measure intersection of two perpendicular diameter and average of this measurement indicates concrete flow.

In addition, time (second) to reach 500 mm has to be record regarding demarcation on the slump test screen which implies that rate of deformation with definition of distance flow. With L-BOX test we can measure height of fresh SCC after embedding it along the steel rebar and flowing in certain direction so that we can estimate power of passing and blockage which must be at least 0.8. Results of physical properties of fresh SCC is shown in Figure (1) (2) (3). According to European standards, slump must be in the span of 60-75 and time T_{50} must be at least 3 second and 6 second at the most.

Hardened concrete

Compression strength and Young's modulus

Test of tensile strength was implemented based on (B.S 1881: Part 116) standard. Curing condition and experiment parameters were the same in experiments which results is shown in Table(4) and figures(4) and (6). We used cylinder specimens (32*15) in order to analyze Young's modulus (ASTMC 469).

Tensile strength

Tensile strength of the concrete is determined by indirect test methods: (1) split cylinder test (2) flexure test, for this study, we wanted to have more invariable results so that we applied split cylinder test accordance to ASTM-C469, which results are shown in (5a) (5b) (5c).

The bending strength and bending endurance tests

In this experiment, we aimed to determine modulus of rupture and bending endurance according to ASTM C78 and ASTM C1018-94b, which was implemented on the specimen (52*12*12) by universal device which has a strain control mechanism with velocity of 0.5 mm/min. furthermore, distance between two supporters was 40 cm.

CONCLUSION

Pursuant to results of workability of self-compact concrete, we considered that using fibers has negative effect in rheology properties of fresh SCC, and it reduce workability and increase both consistency and viscosity.
Considering this fact that fibers inherently have acceptance performance against tensile and bending, our results demonstrate that the more we use fibers the more we have resistance against bending and tensile and the more brittle it can be before rupturing.
In this experimental study, concretes have different fibers, have different mechanical properties. Inasmuch as for concretes which own polypropylene fiber, increasing fiber percent till 0.3%, we encountered that compression strength would be decreased. This downward trend also applies to concrete containing glass fibers.
Our experiments demonstrated that effect of combined polypropylene and glass fibers lead to diminish compression strength, however, with substitution of 0.3% of volume of fibers in combination especially in (0.1P.P+0.2 Glass), we see the maintain of compression strength.
Our experiments demonstrated that in concretes contain

polypropylene and glass fibers, the more we add fibers the more resistance of tensile and bending strength we get.

In the existing mix, if we increase fibers to add in self-compact concrete, we will see exceedingly resistance of tensile and bending strength.

From our results we can assert that polypropylene and glass fibers had slightly changes and they caused to diminish Young's modulus. Effect of combined polypropylene and glass fibers lead to decrease Young's modulus.

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