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Behavior of Synthetic Fibers Incorporated in Self Compacting Concrete Slabs Under Punching Shear

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ABSTRACT
Self compacting concrete differs from conventional concrete by its fluid nature. It fills every corner of the structure by its own weight and it does not require any supplementary compaction technics. This study deals with the effect of macro synthetic fibers (MSF) incorporated in self compacting concrete (SCC) two way slabs under punching shear at simply support and fixed end conditions. In the study eight concrete mixes were prepared with various materials. Hear cement was partially replaced with Fly ash (FA), Silica fume (SF), Ground Granulated Blast Furnace Slag (GGBS) and Manufacture sand (M Sand) is used as fine aggregate. MSF were added in percentages of 0%, 0.5%, 1% and 1.5% to the mixes. As per EFNARC guidelines filling ability and passing ability tests were conducted. Forty eight sample slabs of dimension 600 mm *600 mm*100 mm size two way slabs. The tests were conducted on slabs for simply support and fixed end conditions were subjected to punching shear at center point. The test results compared with 0% fiber sample.

KEY WORDS: Self compacting concrete, cement, fly ash, silica fume, ground granular blast furnace slag, manufacture sand, punching shear, macro synthetic fibers, workability and two way slabs.

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I. INTRODUCTION

General concrete gives poor performance in strength due to insufficient compaction at vibration restricted areas. Usually slabs have small thickness compared to beams and congested reinforcement. The conventional concrete is not placed well at bottom part. Hence we require better workable concrete which flows to every corner and places with zero voids at that place. This can be achieved by using SCC. Non-essentiality of compaction will result in numerous other advantages. It was greatest technological advancement and most revolutionary development in concrete technology over the years, at least from 1980 till date. Many researches were done on SCC to improve strength property of concrete by using different type of fibers under different loads [6]. The optimum percentage of fiber dose influences the workability of concrete during the placing and mixing operations, that percentage varies from 0.5% to 2.5% [4]. Aspect ratio also influences the workability of concrete;aspect ratio is the ratio of length to diameter of fiber. Increase in the aspect ratio up to 75, there is increase in relative strength and toughness [Mustafa, PT-301513].

This project work was an extension of M Chandrakanth's [3] project, in which fresh properties and hardened properties of different mix proportions of silica fume, GGBS and MSF were evaluated. In that study mainly the effect of MSF on the fresh and harden properties of concrete were presented. In the present study the effect of synthetic fibers incorporated in two way slabs under punching shear were evaluated. Punching shear is one of the main risks in slabs which can lead to great damage. It commonly occurs around the contacted line of column and slab. Brittle and abrupt nature of concrete causes collapse of structure (Fethisermith 2016). This project aims to know the effect of macro synthetic fiber in SCC slabs under punching shear.

II. LITERATURE REVIEW

BOBBY RAMTEKE [1] research conducted SCC by comparing different fibers Nylon, Hybrid fibers adding with 0.9 proportion only and SCC without fiber. The study concluded as nylon synthetic fibers increase in compressive strength 6.59% and 18.76%, at age 7 and 28 days respectively.

S.N. PATIL [2] compared normal concrete with polypropylene incorporated SCC with 0%, 0.25%, 0.5%. This study concluded as addition of fibers increases the flexural strength of concrete.

M.CHANDHRAKANTH [3] study on fresh and harden properties of self compacted concrete added with synthetic fibers 0%, 0.5%, 1%, 1.5% percentages. Result given as workability, filling and passing abilities are decreases with increase in percentage of fiber, and harden properties increase with increase in fiber percentage.

FETHI SERMET [4] researches on behavior of SCC slabs under punching shear with fibers, to avoid brittle failure of slabs. Result as displacement of synthetic fibers more than that of steel fibers.

SAAID I.ZAKI [5] explained steel fiber proportion increases then flexural strength of SCC slabs increases.

S. DEEPA SHRI [6] explained flexural behavior of Ferro cement slabs contain polypropylene fibers, and study about with of cracks formed. He concluded load carrying capacity, energy absorption, strength were increases with increase in fiber and crack with is reduced but no of cracks were increased.

MOHAMED S. ISSA [7] tests conducted on both normal concrete and SCC slabs under line load at middle result indicated as normal concrete given better performance in load bearing but more time taking than SCC.

KHALED S. RAGAB[8] explained effect of steel fiber at various percentages in slabs under punching shear.

MALIK K. ALTAEE[9] explained filling, passing abilities and load baring capacity was reduces with increasing the percentage of recycled coarse aggregate.

Dr.MUTAZ KADHIM MEDHLOM[10] explained 50 mm thick slabs deflection at ultimate load(22.99,42.66 and 81.3)% increased considerably by increasing steel fiber (0,1 and 2)% presents

The previous studies indicated that hardened properties are enhanced with increase fiber content. There is scope to extend the study to slabs. In this research, study about effect of MSF incorporated SCC slabs under punching shear. This project is continuation of MChandrakanth's [3] project.

III. OBJECTIVE

The objective of this work was to know the effect of MSF on two way SCC slabs of subjected to punching shear. The study included investigation of SCC with fiber content as 0%, 0.5%, 1%, and 1.5%. In this study cement content was restricted to 65% and remaining 35% of cement was replaced with admixtures i.e., Silica fume, GGBS and Fly ash. The experiment was conducted on two way slabs for simply supported and fixed end conditions under punching shear. Comparative study of test result was carried out for mixes of varying fiber content.

IV. MATERIALS USED

4.1. Cement:

Maha OPC (ordinary Portland cement) 53 grade cement was used. The cement properties are given in table 1.

4.2. Fine aggregate

Manufacture sand (M Sand) passing through 4.75mm IS Sieve conforming to grading of Zone II as per IS 383-1970 was used. Various tests were conducted on the fine aggregate, and results given in table 1.

4.3. Coarse aggregate

12.5 mm crushed stone which is locally available, passing through 12.5mm sieve and retained on 10mm sieve which conforms to IS: 383-1970 was used. It is free from organic matter and impurity such as dust, clay particles is used. Physical properties of the constituent materials of concrete are given in table 1.

Table 1: Physical properties of materials

S.No.	Name of the material	Physical properties	
1	Cement	Specific gravity	3.10
		Fineness m^2/kg	295
		Initial setting time	29 minutes
		Final setting time	240 minutes
		Normal consistency	29%
2	Fine aggregate	Specific gravity	2.58
		Fineness m^2/kg	2.6

		Water absorption	2.31%
3	Coarse aggregate	Specific gravity	2.62
		Water Absorption	0.35%
		Bulk density	1600 Kg/m^3

4.4. Fly ash

Fly ash was obtained from Rayalaseema thermal power plant (RTPP), Muddanur, AP. Physical properties are given in table 2.

4.5. Silica fumes

Silica fume improves mechanical properties of fresh concrete. It was obtained from Lankalapalem pharmaceutical company, AP. Silica fumes properties are given in table 2.

4.6. Ground Granulated Blast Furnace Slag

GGBS is a mineral admixture of concrete. It improves rheological properties. It wasobtained from Vizag steel plant AP. Properties are given in table 2.

Table 2: Properties of the mineral admixtures

S.No.	Name of the material	Physical property	
1	Class F fly ash	Specific gravity	2.5
2	Silica fume	Specific gravity	2.31
3	GGBS	Specific gravity	2.8

4.7. Chemical admixtures

Chemical admixtures are generally used in SCC to give better workability. DCP Supaflo PC360M super plasticizer was used as a chemical admixture. It increases the workability without adding water content.

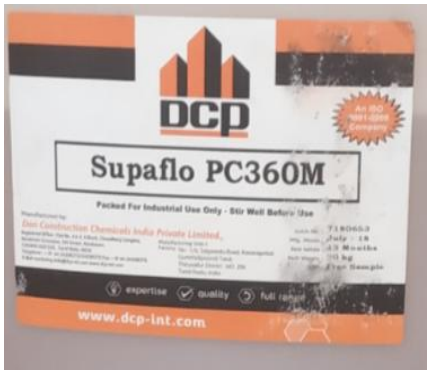


Figure1. Super plasticizer

Properties of super plasticizer are given in table 3.

Table 3. Properties of the Super plasticizer

S.No.	Property	Value
1	Name of chemical	Supaflo PC360M
2	Specific gravity	1.070
3	pH	6.7
4	Solid content	22.95%
5	Color	Pale yellow

4.8. Fibers

MSF used in the project are made of nylon. These are non-biodegradable and flexible. Propertiesof MSF are given table 4.

Figure 2. Synthetic fibers

Table 4 . Properties of Macro synthetic fibers

S.No.	Property	Result
1	Polymer	Polyolefin
2	Length	21-44 mm
3	Diameter	< 0.9 mm
4	Surface texture	Continuously dinted

4.9. Water

Potable tap water was used. Water was free from toxic materials and salts.

V. EXPERIMENTAL WORK

The concrete was prepared by above materials and binding material replaced with various admixtures Fly ash, GGBS and Silica fume; cement content was constant at 65%. Natural sand was substituted with M-sand. MSF were added by proportions of 0%, 0.5%, 1%, and 1.5%. In total eight mixes proportions were arrived at. The number of test specimens was forty eight. Testing of specimens carried out after a curing period of 28 days.

5.1. Mix design

Mix design was done according to the one from the reference paper of M.Chandrakanth [3]. Out of 24 mixes considered in the reference paper, only 8 mixes wereopted. All these mixes conformed to thelimits of fresh properties as per the EFNARC guidelines. M1, M3, M5 and M7 mixes were prepared with 0% of Silica fume and 0%GGBS and 35% fly ash, with0%, 0.5%, 1% and 1.5% fiber proportions respectively. M2, M4, M6 and M8 were prepared with 5% of Silica fume and 5% GGBS and 25% fly ash, with 0%, 0.5%, 1% and 1.5% fiber proportions respectively. The mix proportions are stated in table 5.

Table 5. Mix proportions

Mix name	Cement (kg/m^3)	Fly ash (kg/m^3)	Fa (kg/m^3)	Ca (kg/m^3)	Fibers (%)	Silica fume (kg/m^3)	GGBS (kg/m^3)	Water (kg/m^3)	Admixture (kg/m^3)
M1	345	186	891	810	0	0	0	186	4.7
M2	345	133	891	810	0	26.55	26.55	186	4.7
M3	345	186	891	810	0.5	0	0	186	4.7
M4	345	133	891	810	0.5	26.55	26.55	186	4.7
M5	345	186	891	810	1.0	0	0	186	4.7
M6	345	133	891	810	1.0	26.55	26.55	186	4.7
M7	345	186	891	810	1.5	0	0	186	4.7
M8	345	133	891	810	1.5	26.55	26.55	186	4.7

5.2. Fresh properties

Fresh properties of each mix were found by Slump test, V funnel, L box, and U box tests. The test results were within EFNARC limits. Table 6 shows the limits of fresh properties as suggested by EFNARC. Table 7 shows the fresh properties of all the mixes for which the studies are conducted.

Table 6. EFNARC Limits

PROPERTY	TEST METHOD	EFNARC LIMITS	UNITS
Filling ability	Slump flow	650-800	Mm
	T_{50cm} flow	3-5	Sec
	V funnel	6-12	mm
Passing ability	L box	0.8-1.00	h_2/h_1 mm
	U box	0-30	h_2-h_1 mm

Table 7. Fresh properties of various mixes

S.no	Mixes	Slump flow	T_{50} flow	L box	V box	U box
1	M1	755	3.166	0.976	7.12	6.7

2	M2	748	3.322	0.967	7.55	10.2
3	M3	734	3.284	0.952	7.75	9.6
4	M4	728	3.544	0.942	8.24	12.6
5	M5	712	3.424	0.912	8.15	13.5
6	M6	704	3.712	0.896	8.62	15.7
7	M7	684	3.592	0.886	8.68	15.6
8	M8	676	3.845	0.871	9.18	17.3

From the above Table mixes M1 to M8 values all are satisfied filling and passing ability test values under EFNARC code limits.

5.3. Casting

Fresh concrete obtained from above proportions was cast into slabs without using any compaction implements.The clear dimensions of mould are 600 mm * 600 mm *100 mm.Three samples for each mix proportion were produced. Reinforcement mat of 5 bars of 10 mm diameter in both the directions were placed at bottom of specimen. In total 48 slabswere casted. The slabs were cured for a period of 28 days.

VI. TESTING OF SLABS

6.1 Testing of slabs forsimply supported condition

After casting and curing, the samples were taken out and dried before testing. The position of supports, central load position and dial gauge were marked. The central deflection of the slab was measured at center with the help of electronic device provided at bottom side of the specimen. Load was applied by hydraulic frame machine. Load was applied gradually bit by bit; reading was taken from load dial gauge. Twenty four slab specimens were tested under punching shear for simply supported condition;theset up of which is shown in Figure 3.

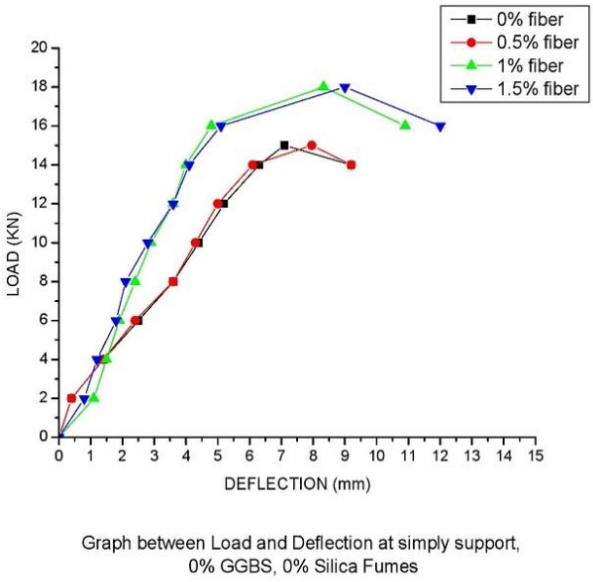
Figure3. Punching test set up for simply support condition

Table 8 shows the magnitude of punching loads and respective deflection values of all the test specimens for simply supported condition.

Table 8. Punching load and deflection values of test specimens-Simply supported

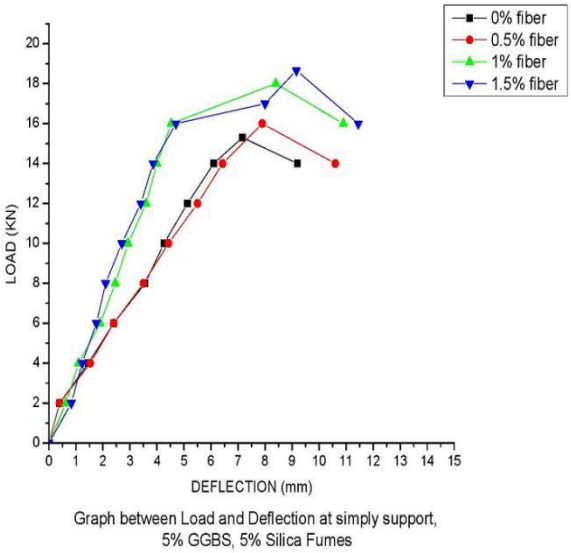
S.No.	Mix name	Simply supported	
		Load(KN)	Displacement(mm)
1	M1	15	7.1
2	M2	15.3	7.16
3	M3	15	7.96
4	M4	16	7.9
5	M5	18	8.33
6	M6	18	8.4
7	M7	18	9.0
8	M8	18.66	9.16

The mixes M1, M3, M5 and M7 have 65% cement,35% fly ash with respective fiber content 0%, 0.5%, 1% and 1.5%. Similarly M2, M4, M6 and M8 have 65% cement,25% fly ash,5% silica fume and 5% GGBS with respective fiber content 0%, 0.5%, 1% and 1.5%. The graphical representation of the values of table 7 is depicted in figures 4 and figure 5.



Graph between Load and Deflection at simply support, 0% GGBS, 0% Silica Fumes

Figure 4



Graph between Load and Deflection at simply support, 5% GGBS, 5% Silica Fumes

Figure 5

From figures 4 and 5, it is evident that the capacity of SCC to take up shear load increase with an increase in fiber content. Among the mixes M1, M3, M5 and M7,the maximum load was 18KN.Among the mixes M2, M4,M6 and M8,the maximum load was 18.33KN.

6.2 Testing of slabs forfixed end support condition

After casting and curing, the samples were taken out and dried before testing. The position of supports, central load position and dial gauge were marked. The central deflection of the slab was measured at center with the help of electronic device provided at bottom side of the specimen. Load was applied by hydraulic frame machine. Load was applied gradually bit by bit; reading was taken from load dial gauge. Twenty four slab specimens were tested under punching shear for fixed end support condition; the set up of which is shown in Figure 6.

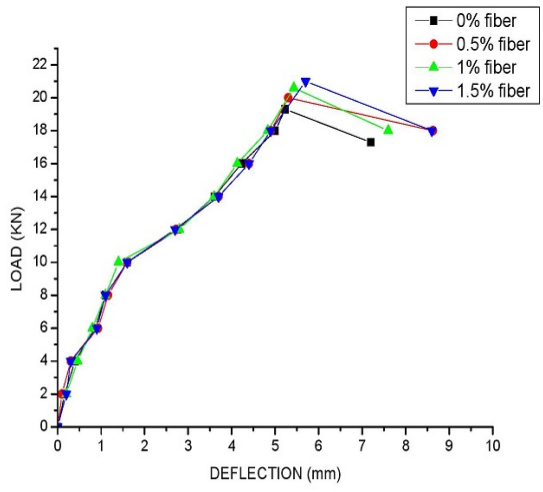
Figure 6. Punching test set up for fixed support

Table 9 shows the magnitude of punching loads and respective deflection values of all the test specimens for fixed support condition.

Table 9.Punching load and Deflection values of test specimens-Fixed support

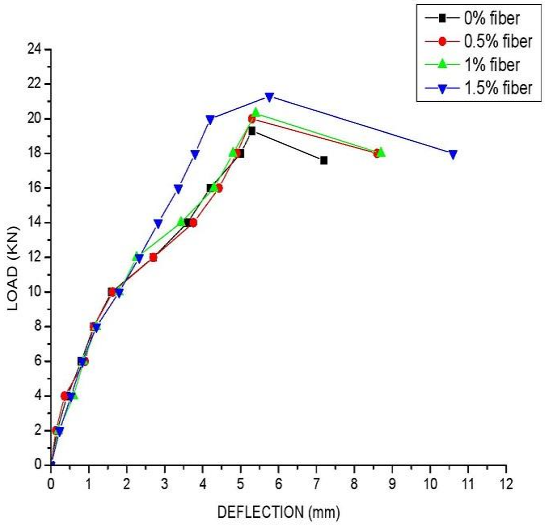
S.No.	Mix name	Fixed support	
		Load(KN)	Deflection(mm)
1	M1	19.3	5.23
2	M2	19.3	5.3
3	M3	20	5.3
4	M4	20	5.3
5	M5	20.6	5.43
6	M6	20.3	5.4
7	M7	21	5.7
8	M8	21.3	5.76

The mixes M1, M3, M5 and M7 have 65% cement,35% fly ash with respective fiber content 0%, 0.5%, 1% and 1.5%. Similarly M2, M4, M6 and M8 have 65% cement, 25% fly ash,5% silica fume and 5% GGBS with respective fiber content 0%, 0.5%, 1% and 1.5%. The graphical representation of the values of table 7 is depicted in figures 7 and figure 8.



Graph between Load and Deflection at fixed support, 0% GGBS, 0% Silica Fumes

Figure 7



Graph between Load and Deflection at fixed support, 5% GGBS, 5% Silica Fumes

Figure 8

From figures 7 and 8, it is evident that the capacity of SCC to take up shear load increases with an increase in fiber content. Among the mixes M1, M3, M5 and M7,the maximum load was 21KN.Among the mixes M2, M4, M6 and M8,the maximum load was 21.3KN.

VII. CONCLUSION

Based on the results of these experimental investigations, the following conclusions can be deduced.

- An increase in fiber content from 0% to 1.5% resulted in increase in punching load value of simply supported slabs by 20% for mixes in flyash was used as mineral admixture.
- An increase in fiber content from 0% to 1.5% resulted in increase in punching load value of

simply supported slabs by 21.9% for mixes in three mineral admixtures were used.

- In fixed slabs also rise in fiber content from 0% to 1.5% resulted in enhanced punching load value of fixed slabs by 8.8% for mixes in fly ash was used as mineral admixture. The effect of fibers is less pronounced in the case of fixed slabs.
- Fixed slabs with 1.5% fiber content has increased punching load by an amount of 10.3% as compared to those with 0% fiber content. This was noticed in mixes in which fly ash, SF and GGBS were used as pozzolanic materials.
- Deflection of slab has increased by 26.76% in simply supported slab due to increase in fibercontent from 0% to 1.5%in mixes with a single mineral admixture.
- With an increment in fiber contentfrom 0% to 1.5% in triple blended simply supported concrete slabs,rise in deflection of slabs by 27.9% when compared with 0% fiber mix.
- For the fixed end condition, the deflection has incremented by 8.9% in mixes with single mineral admixture for samples with 1.5% MSF in comparison with plain SCC mixes.
- Similarly, in triple blended concrete for fixed end condition slabs, an increase in fiber content from 0% to 1.5%followed an increase in deflection by 8.3%.
- Effect of macro synthetic fiber on deflection and punching shear values is more evidentin the case of simply supported condition when compared to that on fixed end condition.
- Effect of GGBS and silica fume on deflection and punching shear values is more prominent in the case of simply supported condition when compared to that on fixed end condition.

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