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MECHANICAL PROPERTIES OF SELF COMPACTING CONCRETE WITH GLASS FIBERS

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Abstract - *Self-compacting concrete (SCC) is a concrete which has a high flowing ability with no segregation and which compacts under its own weight. Self-compacting concrete is combined with glass fibers to create glass fiber reinforced self-compacting concrete (GFRSCC). This thesis details the mechanical properties of Self-compacting concrete using four percentages of glass fibers i.e., 0%, 0.1%, 0.15%, 0.2%. Experimental investigation is carried out to find out Mechanical properties of Self-compacting concrete in fresh and hardened states. Compressive strength, Split tensile strength, Flexural strength, Durability, Load Vs Deflection characteristics are found by using different percentages of glass fibers for M30 & M40 grades and comparative study is made. Analytical models are developed by using ABAQUS software for M30, M40 grade plane SCC. Mix design was performed by following all the EFNARC Guidelines and laboratory tests were conducted to verify the properties of self compacting concrete. Water-cement ratio is 0.38 and fly ash was replaced with 30% by weight of cement.*

Key words: S.C.C, Glass fibers, Fly ash, ABAQUS

1. INTRODUCTION

1.1 Self compacting concrete

Self-compacting concrete is considered to be the most revolutionary invention in concrete technology

Self-compacting concrete has high flowing ability and has the ability to compact under its own weight, its high flowing ability helps its to flow throughout the formwork and helps in filling all over the reinforcement without vibration. Self-compacting has a benefit of filling congested reinforcement.

Self-compacting concrete was first developed in 1986 in Japan by Okumura. Studies to develop SCC, including a fundamental study on the workability of concrete, have been carried out by "Ozawa and Maekawa" at the university of Tokyo. In 2002 EFNARC has published their "Specification & Guidelines for Self-Compacting concrete". The EFNARC in its publication has specified mix compositions which should be followed while preparing the mix design, it also specified the acceptance criteria for the fresh SCC. The table1 shows the acceptance criteria limits proposed by EFNARC guidelines.

Method	Property	Unit	Min.	Max.
Slump flow	Filling ability	Mm	650	800
T50cm slump flow	Filling ability	Sec	2	5
V-funnel	Filling ability	Sec	6	12
V-funnel 5min	Segregation resistance	Sec	6	15
L-box	Passing ability	H2/ H1	0.8	1.0

Table 1 Acceptable criteria for workability of fresh SCC

2. Materials used in SCC

The materials used in SCC are Cement, Coarse aggregate, Fine aggregate, Fly ash, Glass Fiber (cem-fill anti crack high dispersion glass fiber)**,** Super plasticizer (Conplast Sp550), water. The description of each material is given below

Cement
Cement used in this study was KCP brand ordinary Portland cement of 53 grade. The specific gravity of cement is 3.15, the initial and final setting times are 35min and 10hrs respectively.

Coarse aggregate
Locally available graded aggregate of maximum size 16mm is used in this present study. The specific gravity of coarse aggregate was 2.73, Bulk density (loose) and bulk density (compacted) are 1549kg/m^3 and 1716kg/m^3.

Fine aggregate
The fine aggregate used in this study was procured from the bank of river Krishna and conformed to grading zone III. The Specific gravity of fine aggregate was 2.62 and moisture content was 2%

Fly ash

Fly used in this study was collected from VTPS, Kondapalli, Vijayawada. The specific gravity of fly ash is 2.6 and its color is whitish grey.

Glass fiber

Glass fiber used is cem-fill anti crack high dispersion glass fiber with Filament length 12mm, Filament diameter 14micron, Aspect ratio of 857:1 were used throughout the study.

Figure 1 Glass fiber

Super plasticizer

Super plasticizer used in this study is Conplast SP550 and its dosage is 8ml to 13ml.

Water

Ordinary tap water was used.

3. EXPERIMENTAL PROCEDURE

Two self-compacting mixes with M30 and M40 grades are developed by satisfying all the workability properties of EFNARC guidelines. The mix details were given below

Table2 mix proportions forM30 grade

Cement (kg/m³)	Fly ash (kg/m³)	F.A (kg/m³)	C.A (kg/m³)	Water (kg/m³)	S.P ml
336	144	871.9	907.72	182.4	10
Cement (kg/m³)	Fly ash (kg/m³)	F.A (kg/m³)	C.A (kg/m³)	Water (kg/m³)	S.P ml
350	150	837.33	865.35	190	8

Table3 mix proportions for M40 grade

These developed mixes were checked for workability properties by using different percentages of glass fibers. The results of workability properties by using different percentages of glass fibers for two grades are shown in table 4 and table 5

Table 4 workability properties for M30 grade

S.NO	Method	units	0% glass fiber	0.1% glass fiber	0.15% glass fiber	0.2% glass fiber
1	Slump flow	mm	672	670	667	663
2	T 50 slump	sec	4.26	4.35	4.56	4.62
3	V-funnel	sec	8.5	9.1	9.43	10.22
4	V-funnel at 5min	sec	10	10.54	10.32	11.1
5	L-box	h_2/h_1	0.83	0.85	0.9	0.93

Table 5 workability properties for M40 grade SCC

S.NO	Method	units	0% glass fiber	0.1% glass fiber	0.15% glass fiber	0.2% glass fiber
1	Slump flow	mm	678	675	669	661
2	T 50 slump	sec	4.42	4.53	4.69	4.76
3	V-funnel	sec	8.7	9.23	9.54	10.31
4	V-funnel at 5min	sec	10.3	10.72	10.95	11.36
5	L-box	h_2/h_1	0.86	0.89	0.92	0.97

Figure 2 casting of cubes, cylinders and beams

3.1 Compressive strength test

The 28 days compressive strength have been calculated for both grades of concrete.

Cubes of size 150mmx150mmx150xmm are casted and have been cured in water and then removed in water and dried then calculated for compressive strength. The compressive strength results for 28 days for cubes using different percentages of glass fibers are shown in the table 6

Table 6 Compressive strength results for 28 days

% of fiber	Compressive strength	
	M30 grade	M40 grade
0	34.84	45.32
0.1	39.02	47.86
0.15	41.12	49.51
0.2	42.36	51.32

3.2 Split tensile strength test

The 28days split tensile of concrete has been found by casting cylinders of size 200mmx100mm by using different percentages of glass fibers. They are then cured in water for 28 days and then removed and been tested. The 28 days split tensile strengths are shown in table

Table 7 Split tensile strength results for 28 days

% of fiber	Split tensile strength	
	M30 grade	M40 grade
0	3.25	4.62
0.1	3.56	4.89
0.15	3.91	5.12
0.2	4.14	5.43

3.3 Flexural strength test

The 28 days flexural strength of beams by using different percentages of fibers were calculated by casting beams of size 500mmx100mmx100mm and curing for 28 days. The results are shown in table

Table 8 Flexural strength results for 28 days

% of fiber	Flexural strength	
	M30 grade	M40 grade
0	5.35	8.35
0.1	7.46	9.23
0.15	8.16	11.63
0.2	9.23	12.85

3.4 Durability test

Cubes of size 100mm with different percentages of glass fiber are caste for both grades and are cured in water for 28 days they are then removed and immersed in 3% H_2SO_4 solution for 28 days and are removed and tested for percentage weight loss and compressive strength loss

Table 9 percentage loss in weight and durability

%of fibers	% Loss in weight		%loss in compressive strength	
	M30	M40	M30	M40
0	18.59	19.63	14.98	23.05
0.1	15.60	11.36	8.58	19.72
0.15	11.54	11.64	7.90	13.22
0.2	8.47	8.28	6.90	14.8

Figure 3graph for M30 grade %loss in weight and compressive strength

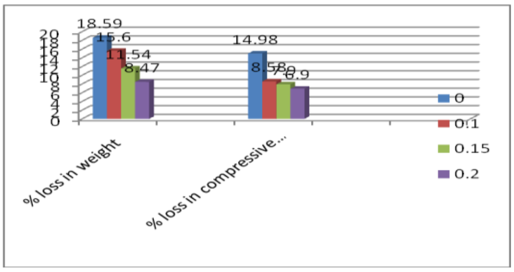
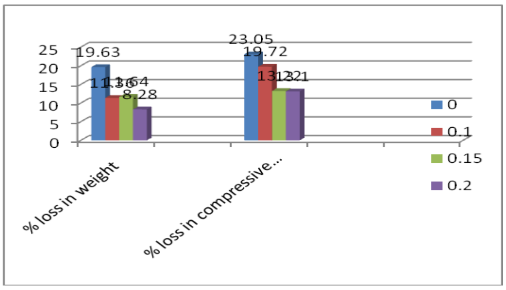


Figure 4 graph for M40 grade %loss in weight and compressive strength



3.5 Behavior in flexure

Beams of size 1000mmx230mmx300 mm with 2-12mm dia main bars, 2-10 mm dia secondary bars and 4 stirrups of 8mm dia with 300mm spacing have been designed and casted by using different percentages of glass fibers for both M30 and M40 grades. Curing have been done for 28 days and then the beams have been tested upto ultimate loading on loading frame setup.

Figure 5 beam reinforcement and mould

Figure 6 casting of beam

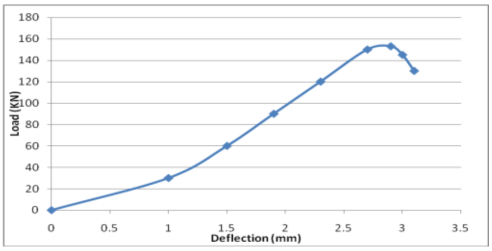
Figure 7 loading frame setup

3.6 LOAD Vs DEFLECTION CHARACTERISTICS

3.6.1 M30 beam with 0% glass fiber

The beam (M30+0% fiber) reached a ultimate load of 153KN and the first crack was observed at a load of 110.45KN. The maximum deflection observed at ultimate load is 2.9mm.

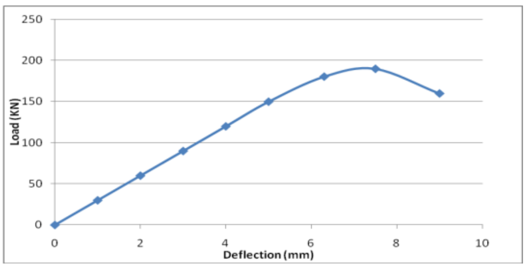
Figure 8 Load Vs deflection graph for M30 beam with 0% glass fiber



3.6.2 M30 beam with 0.1%glass fiber

The beam (M30+0.1% fiber) reached a ultimate load of 180.5 KN and the first crack was observed at a load of 132.8 KN. The maximum deflection observed at ultimate load is 6.3mm

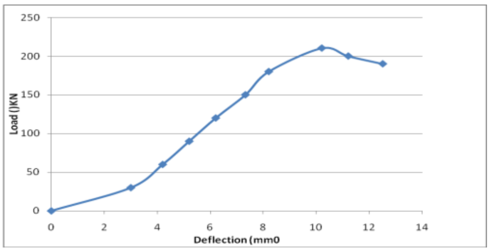
Figure 9 Load Vs deflection graph for M30 beam with 0.1% glass fiber



3.6.3 M30 beam with 0.15%glass fiber

The beam (M30+0.15% fiber) reached a ultimate load of 210.3 KN and the first crack was observed at a load of 186.7KN. The maximum deflection observed at ultimate load is 10.2mm.

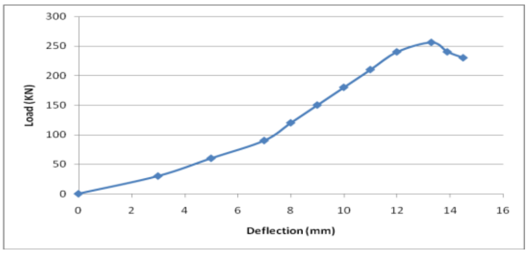
Figure 10 Load Vs deflection graph for M30 beam with 0.15% glass fiber



3.6.4M30 beam with 0.2%glass fiber

The beam (M30+0.2% fiber) reached a ultimate load of 246 KN and the first crack was observed at a load of 205.6 KN. The maximum deflection observed at ultimate load is 13.3mm.

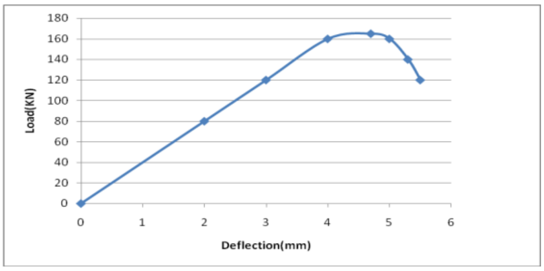
Figure 11 Load Vs deflection graph for M30 beam with 0.2% glass fiber



3.6.5 M40 beam with 0% glass fiber

The beam (M40+0% fiber) reached a ultimate load of 172.5KN and the first crack was observed at a load of 125.8KN. The maximum deflection observed at ultimate load is 4.5mm.

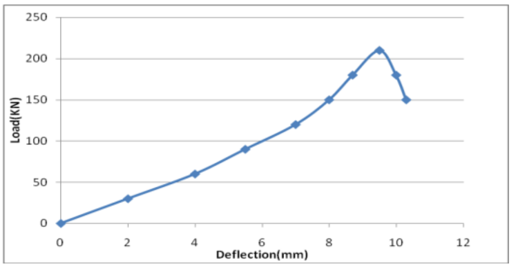
Figure 12 Load Vs deflection graph for M40 beam with 0% glass fiber



3.6.6 M40 beam with 0.1%glass fiber

The beam (M40+0.1% fiber) reached a ultimate load of 210 KN and the first crack was observed at a load of 185 KN. The maximum deflection observed at ultimate load is 9.5mm.

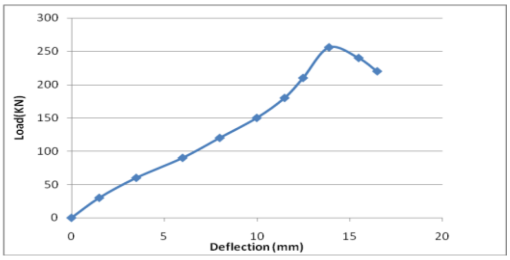
Figure 13 Load Vs deflection graph for M40 beam with 0.1% glass fiber



3.6.7 M40 beam with 0.15%glass fiber

The beam (M40+0.15% fiber) reached a ultimate load of 256 KN and the first crack was observed at a load of 219.5 KN. The maximum deflection observed at ultimate load is 13.9mm.

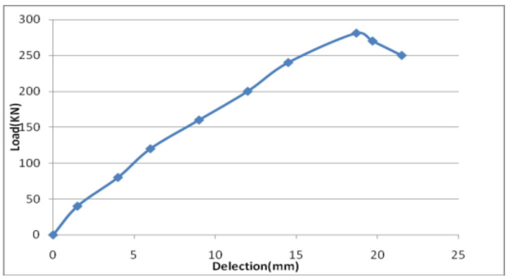
Figure 14 Load Vs deflection graph for M40 beam with 0.15% glass fiber



3.6.8 M40 beam with 0.2%glass fiber

The beam (M40+0.2% fiber) reached a ultimate load of 281 KN and the first crack was observed at a load of 235.2 KN. The maximum deflection observed at ultimate load is 18.7mm.

Figure 15 Load Vs deflection graph for M40 beam with 0.2% glass fiber



3.7 Model generation in abaqus and comparison of results

Analytical models have been generated for M30 & M40 grade SCC beams with 0% glass fibers and the results obtained are compared with experimental study done on M 30 and M40 grade SCC beams

Figure 16 Assembly of elements

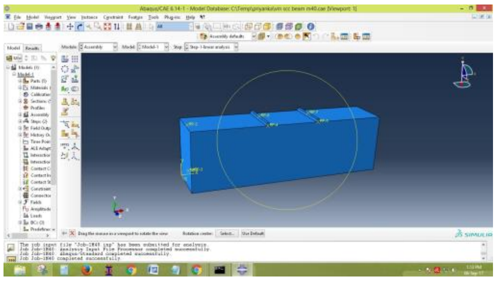


Figure 17 Meshing

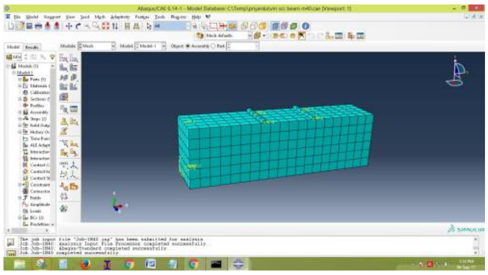


Figure 18 Reinforcement detailing

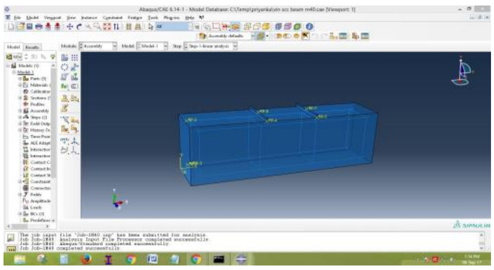


Figure 19 Stresses

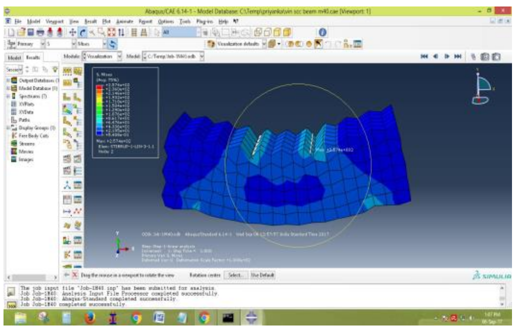
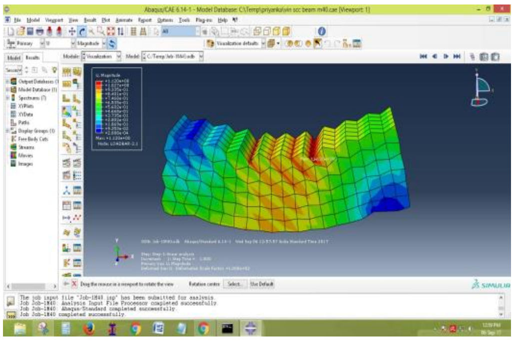


Figure 20 Deflection



3.7.1 Comparison of analytical and experimental results

The analytical and experimental results have been compared and the comparison is shown in the table below

Table 9 comparison on analytical and experimental results

Grade	Experimental results		Analytical results	
	Load (KN)	Deflection (mm)	Load (KN)	Deflection (mm)
M30	153	2.9	160.6	3.3
M40	172.5	4.5	181.3	4.9

CONCLUSIONS

1. From the above discussion it is observed that with the increase in the percentage of fibers the workability of the self-compacting concrete decreased.

2. For both M30 and M40 grades there was increase in compressive strength, split tensile strength, flexural strengths with the increase in the percentage of fibers

3. The percentage loss in weight and percentage loss in compressive strength were found to be decreased with increase of glass fiber percentage for both M30 and M40 grades

4. The Load carrying capacity and deflection were found to be increasing by increase in percentage of fibers for both grades of concrete.

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