Steel Fibre Reinforced Self-Compacting Concrete-Concrete for The Next Generation

[1]Dr.Nadeem Pasha, Assistant Professor, Faculty of Engineering & Technology,
Department of Civil Engineering, Khaja Bandanawaz University, Kalaburagi, Karnataka, India,
nadeem@kbn.university
[2]Dr.Shaik Kamal Md Azam, Professor & Dean Faculty of Engineering & Technology,
Department of Civil Engineering, Khaja Bandanawaz, University, Kalaburagi, Karnataka, India,
azam@kbn.university

ABSTRACT - In this experimental study effect of GGBFS & fly ash on SFRSCC specimen produced by hooked end steel fibers were investigated. The main objective is to obtain Steel Fibre Reinforced Strength Self Compacting Concrete (SFRSCC) which flows under its own weight & homogeneity while completely filling any formwork and passing around congested reinforcement. The SFRSCC was produced by using fly ash, GGBFS and steel fibers and Polycarboxylate-ether base super plasticizer. Hooked End steel fibers were used & volume fractions 0,0.5,1,1.5 & 2% & replacement of GGBS & fly ash into the concrete were 30% & 20% by weight of cement content. Water/cement ratio was 0.40. In general, significant improvement in strengths is observed with the inclusion of GGBFS & Fly ash. The deflection characteristics of SFRSCC were studied by using flexural strength test. A total of twenty beams of size (2300x150x200)mm were casted and tested under two point loading. Two shear span by depth ratios were selected a/d =3.7 & 3.8. The present study focuses on the study of short term & long term deflections of steel fiber reinforced self- compacting concrete by using limit state of serviceability method.The results obtained were again validated by using ETABS. It was observed that by the addition of hooked end steel fibers to SCC its ductility is increased & also by using fly ash 20% & 30% GGBFS, load carrying capacity of the beams is increased & life span of the structures built by using SFRSCC is also increased.

Keywords: Fly Ash, GGBFS, Self Fibre reinforced self -compacting concrete , Strength Parameters, deflection characteristics, Hooked End Steel fibres ,ETABS.

I. INTRODUCTION

Around the world the construction material that is widely used is concrete. Due to technological advancements concrete properties have been undergoing changes. To improve the properties of concrete several types of concrete are developed[5]. Self -compacting concrete (SCC) is one of them. It is not at all a new concrete but it is somewhat complex and developing technology. SCC is a new addition to the construction industry. SCC offers a number of advantages such as filling ability, passing ability and segregation resistance [10]. SCC is widely used were congested reinforcements is required and normal vibration is not possible. The main objective of this research is to produce of Steel Fiber Reinforced Self Compacting Concrete (SFRSCC).But the literature indicates that some studies are available on plain SCC but sufficient literature is not available on Steel Fiber Reinforced Self Compacting Concrete (SFRSCC) with different mineral admixtures and steel fibers. Hence an attempt is made in this work to study the mechanical properties of SFRSCC, a concrete which can increase the life span of structures.

II. LITERATURE REVIEW

Concerning self-compacting concrete, Ozawa et al. [1995] [1] conducted research. The first person to successfully create self-compacting concrete was him. In his initial prototype on SCC, he made use of materials that were readily accessible in the area. He tested several super plasticizers on concrete to determine its workability; the result was a new kind of concrete that was very workable; it was subsequently dubbed self-compacting concrete. In addition, he investigated the workability of SCC by varying the dose of mineral admixture, which included fly-ash and blast furnace slag. He experimented with various mix

 DOI : 10.35291/2454-9150.2024.0365

proportions and found that SCC's flowability and segregation resistance were best achieved with a mixture of 10–20% fly-ash and 25–45% GGBS by mass.

Buquan Miao et.al [2003], [11] conducted the study on the mechanical characteristics and mix design of self-compacting concrete reinforced with steel fibers. The compressive, split tensile and flexural strengths of SFRSCC were investigated after three different dosages of steel fibers 0.5%, 1%, and 1.5 percent by volume of concrete—were tested. Mineral admixtures & superplasticizers, including fly-ash and GGBS, allowed for the satisfaction of new qualities without bleeding or segregation. As the dosage of steel fiber increased, the testing findings portrayed as flow characteristics of SCC drastically decreased. Although self-compacting SFRC's compressive strength decreased as a consequence of the increased air content in SFRSCC, the experimental outcomes portray as increase in steel fiber content might enhance flexural strength & toughness of the material.

Gali and Subramaniuam [2017], [12]investigated the impact upon shear behavior of FRC beams of varying volume fractions of steel fibers (0.5 and 0.75%). Ratio of shear span to depth remained constant at 1.8. Using the digital image correlation (DIC) method, they assessed the cracking behavior of RC beams in this research. The beam study revealed that full depth shear fractures developed in the RC beams prior to the beam reaching its maximum load bearing capability. Crack opening resistance was shown to increase from half a percent to seven percent fiber dose up to peak load.

Shear failure, as described by Narayanan et al. (1987), [4] often results in diagonal fractures appearing in Reinforced Concrete (RC) beams. This happens when the primary tensile stress of the concrete surpasses its tensile strength inside the shear span. Since shear failure is brittle and happens suddenly, there is no way to prepare for it. Reinforcing beams using stirrups at design-determined intervals prevents these kinds of failures. Since shear failure is brittle and happens suddenly, there is no way to prepare for it. Reinforcing beams using stirrups at design-determined intervals prevents these kinds of failures. The shear reinforcement, concrete grade, longitudinal reinforcement percentage & (a/d) are the primary factors that influence the behavior of RC beams. Recent years have seen a rise in the prominence of using short steel fiber in concrete. Main benefits of employing steel fibers are that it increases the ultimate load bearing capacity of concrete beam by bridging and arresting the cracked surfaces. Another advantage is that it increases the flexural tensile strength. The ability of the fibers to bridge the fracture faces, when present in enough quantity, gives SFRC its increased post-cracking behavior. [Cucchiara et al, 2004]. [6]

Sahoo, D.R.Bhagat S. and Reddy [2016][8], tested T-beams reinforced with steel fibers in concrete for ultimate shear resistance and failure modes depending on shear span to depth ratio. In 0.5% increments, they examined steel fiber concentrations from 0% to 1.5%. They investigated 1.6, 2.5, and 3 shear span-to-depth ratios. All shear span-to-depth ratios (a/d) have these benefits. According to experimental results, beams reinforced with fibers shifted from diagonal shear failure to ductile flexural model across all a/d ratios.

III. MATERIALS USED

3.1 Cement: Ordinary Portland Cement of 53 Grade conforming to IS: 12269-1987[13] was used in the investigation. The specific gravity of cement was 3.15.

3.2 Coarse Aggregate: Crushed stone coarse aggregate with a maximum size of 12.5 mm from a local source having the specific gravity of 2.7 conforming to IS: 383-1970 was used.

3.3 Fine Aggregate: Locally available river sand passing through 4.75 mm IS sieve conforming to grading zone-II of IS: 383-1970 was used. The specific gravity of fine aggregate was 2.66

3.4 Fly Ash : Class F fly ash is obtained from Raichur Thermal Power Station, Karnataka state, India. The fly ash properties are tabulated below.The physical properties and chemical composition of fly ash are shown in table1and table 2 respectively.

Sl No	Physical Properties	Test Results
1.	Colour	Grey
2.	Specific Gravity	2.23
3.	Lime reactivity after 28 days, average compressive strength of mixture ‘A’	4.8 Mpa

Table 1: Physical properties of Fly Ash

Sl No	Constituents	Percentage by weight
1.	Loss of ignition	4.15
2.	Silica (SiO_2)	58.66
3.	Iron Oxide (Fe_2O_3)	3.33
4.	Alumina (Al_2O_3)	28.30
5.	Calcium Oxide (CaO)	2.12
6.	Magnesium Oxide (MgO)	0.35
7.	Total Sulplhur (SO_3)	0.06

 DOI : 10.35291/2454-9150.2024.0365

8.	Insoluble residue	-
9.	Alkalis a)Sodium Oxide (Na_2O) b)Potassium Oxide (K_2O)	 0.56 1.28

Table 2 : Chemical properties of Fly Ash

3.5 Ground Granulated Blast Furnace Slag (GGBFS): It is a byproduct obtained from steel production. GGBFS is non-metallic powder which has chemical composition of aluminates and silicates of calcium and other base. GGBFS is a mineral additive that may be used as an admixture in concrete, as its quality is good and consistent. The chemical composition and physical properties of GGBFS are tabulated in the table 3 &4

Sl No	Constituents	Percent by weight
1.	SiO_2	34.30
2.	Fe_2O_3	0.50
3.	Al_2O_3	22.15
4.	CaO	34.40
5.	SO_3	1.75
6.	MgO	8.54
7.	K_2O	0.36
8.	Loss of Ignition	0.16

Table 3: Chemical composition in percentages of GGBFS

Sl No	Physical properties	Test results
1	Physical form	Off white colour
2	Specific surface area	400-600 m^2/Kg
3	Specific gravity	2.75
4	Bulk density (Loose)	1000-1100 Kg/m^3
5	Bulk density	1200-1300 Kg/m^3

Table 4: Physical properties of GGBFS

3.6 Steel Fibres: The main variables used in the study are hooked end steel fibres.

The steel fibres were obtained from Stewols India Pvt Ltd Nagpur. The properties of steel fibres are mentioned in the table 5

Properties	Specifications
Type	Hooked End Steel fibres
Length of Fibre	30
Diameter of Fibre	0.5
Aspect Ratio	60
Tensile Strength	1100 Mpa

Table 5: Properties of hooked end Steel Fibres

3.7 Super plasticizer : In current investigation, water-reducing admixture CHRYSO FLUID. OPTIMA P-77 (poly carboxylic ether based) obtained from Chyrso Chemicals, India was used.

3.8 Water: Fresh portable water is used for mixing the concrete and curing

IV. MIX PROPORTION

Mix design is carried out by IS 456-2000, & IS 10262-2009.Apart from that for SCC Design EFNARC[9] guidelines are followed and Modified Nansu Method[7] was also used. The mix proportion obtained was

 DOI : 10.35291/2454-9150.2024.0365

	Cement	Coarse aggregate	Fine aggregate	S.P	Water
Quantity (kg/m^3)	475.6	796.72	817.6	7.13	180.72
Proportions	1	1.67	1.72	0.015	0.37

Table 6: Mix proportioning of CCM40, CCSCC and cement replaced by fly ash

V. EXPERIMENTAL PROGRAMME

A total of twenty beams were casted and tested under flexure .The load VS deflection curves were plotted. The short term & long term deflection of the beams were tabulated.

CASE: 1 a/d =3.7 660/175 = 3.7 a=660 mm

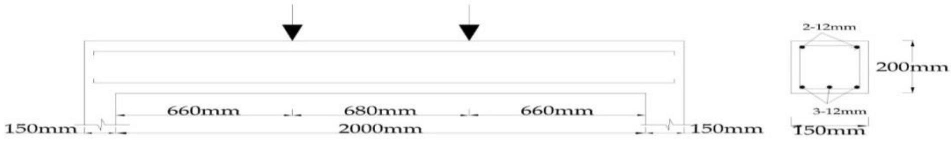

Figure 1: Beam Setup for a/d 3.7 with reinforcement detail

CASE: 2 a/d =3.8 672/175 = 3.8 a=672 mm

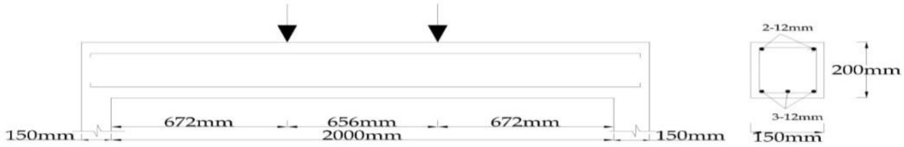

Figure 2: Beam Setup for a/d 3.8 with reinforcement details

5.1. FRESH PROPERTIES OF SCC

Various tests such as slump flow, L-Box and sieve stability test were carried out to determine the workability of SCC[2]. The experimental results for Fresh SCC are listed below

MIX ID	Slump Flow in mm	L-Box Test (h2/h1)	Sieve Stability Test (%)
SFRSCC1	690	0.88	6.50
SFRSCC2	655	0.85	7.25
SFRSCC3	685	0.90	5.65
SFRSCC4	690	0.84	6.20
SFRSCC5	680	0.92	7.70
SFRSCC6	700	0.98	8.50
SFRSCC7	660	0.84	8.25
SFRSCC8	680	0.92	5.58
SFRSCC9	690	0.84	6.65
SFRSCC10	685	0.94	7.20
SFRSCC11	720	0.98	8.25
SFRSCC12	690	0.84	6.60
SFRSCC13	685	0.93	7.25
SFRSCC14		0.97	7.24

 DOI : 10.35291/2454-9150.2024.0365

	694		
SFRSCC15	690	0.82	6.62
SFRSCC16	685	0.92	7.00
SFRSCC17	700	0.97	7.25
SFRSCC18	695	0.88	6.65
SFRSCC19	685	0.92	6.20
SFRSCC20	700	0.97	7.35

Table 7: Experimental Test Results for Fresh SFRSCC

Method	**Unit**	**Property**	**Typical ranges of values**	
			Minimum	**Maximum**
Slump flow	Mm	Filling Ability	650	800
L-box	h2/h1	Passing Ability	0.8	1.0
Sieve Stability Test	%	Segregation Resistance	The mixture belonging to SR2 class SR2 (<15%).	

Table 8: Acceptance criterions for Self-compacting Concrete as per EFNARC specifications

Workability test done satisfies the norms of EFNARC[3] specifications.

5.2 HARDENED PROPERTIES OF CONCRETE

5.2.1 Load VS Deflection Curves

LOAD IN KN	DEFLECTION IN MM				
	SFRSCC1	SFRSCC2	SFRSCC3	SFRSCC4	SFRSCC5
2	0.2	0.2	0.7	0.3	0.6
4	0.4	0.4	2.1	0.5	0.9
6	0.6	0.6	2.2	0.5	1.2
8	0.8	1.2	2.4	0.6	1.4
10	1.1	1.4	2.5	0.7	1.9
12	1.3	1.8	2.7	0.9	2.2
14	1.5	2.2	2.8	1	2.3
16	1.7	2.5	2.9	1	2.4
18	1.9	2.8	3	1.1	2.5
20	2.1	2.9	3.1	1.2	2.6
22	2.3	3.2	3.2	1.3	2.7
24	2.4	3.2	3.3	1.4	2.8
26	2.6	3.3	3.4	1.5	2.9
28	2.7	3.4	3.5	1.6	3.1
30	2.9	3.4	3.5	1.7	3.3
32	3	3.5	3.6	1.7	3.4
34	3.1	3.6	3.7	1.8	3.5
36	3.2	3.7	3.8	1.9	3.6
38	3.4	3.9	3.9	2	3.8
40	3.5	4	4	2.1	3.9

 DOI : 10.35291/2454-9150.2024.0365

42	3.6	4.1	4.1	2.2	4
44	3.7	4.2	4.2	2.3	4.1
46	3.8	4.4	4.3	2.3	4.2
48	4	4.3	4.4	2.4	4.3
50	4.1	4.5	4.5	2.4	4.4
52	4.2	4.5	4.5	**2.5**	4.5
54	4.4	4.6	4.6	2.6	4.6
58	4.6	4.7	4.7	2.6	4.7
60	4.8	4.8	4.8	2.7	4.8
62	4.9	4.8	4.9	2.7	4.9
64	5.2	5	4.9	2.8	5
66	**5.25**	5.1	5	2.9	5.1
68		**5.2**	5.1	3.2	5.2
70			**5.15**	3.5	5.3
72				4	**5.37**
74				**4.15**	

Table 9:Load Deflection for M40 SFRSCC with 20% fly Ash and a/d-=3.7

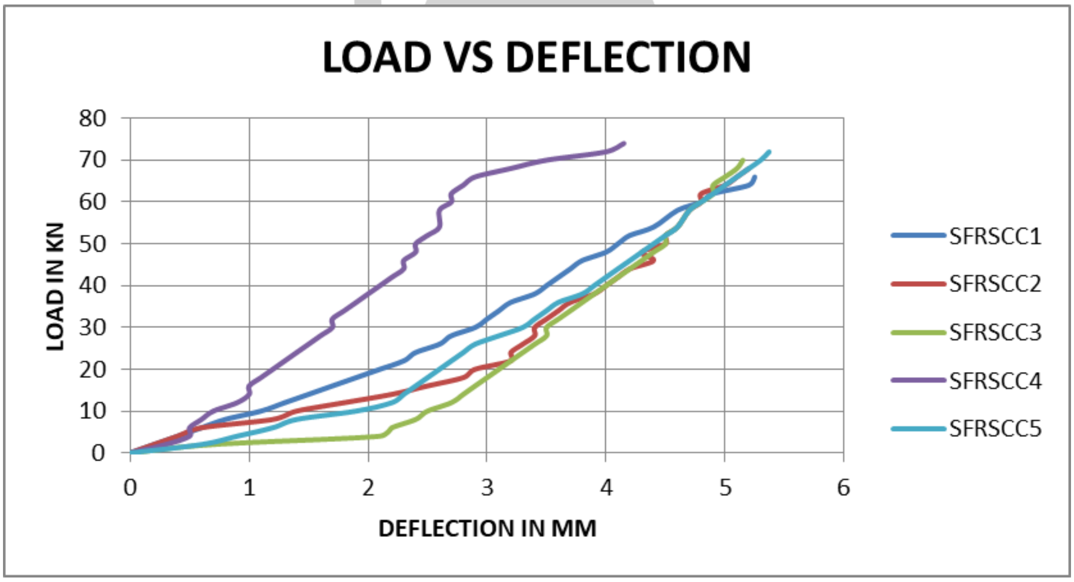

Figure 3: Load Deflection Curve for M40 SFRSCC with 20% Fly Ash and a/d-=3.7

LOAD IN KN	DEFLECTION IN MM				
	SFRSCC6	SFRSCC7	SFRSCC8	SFRSCC9	SFRSCC10
2	0.5	0.4	0.3	0.5	0.5
4	1.3	0.8	0.5	0.7	1
6	1.5	1.2	0.7	0.9	1.2
8	1.6	1.5	0.9	1	1.3
10	1.7	1.7	1.2	1.2	1.4
12	1.8	1.8	1.4	1.3	1.5
14	1.9	1.9	1.6	1.35	1.7
16	2	2	1.8	1.4	1.9
18	2.1	2.2	2	1.5	2

 DOI : 10.35291/2454-9150.2024.0365

20	2.2	2.3	2.2	1.6	2.1
22	2.3	2.4	2.4	1.7	2.2
24	2.35	2.5	2.6	1.8	2.3
26	2.4	2.6	2.8	1.9	2.4
28	2.5	2.75	3	2	2.5
30	2.6	3	3.2	2.1	2.6
32	2.75	3.1	3.4	2.2	2.7
34	3	3.5	3.6	2.3	2.8
36	3.25	3.7	3.8	2.4	2.9
38	3.5	3.8	3.9	2.5	3
40	3.75	3.9	4	2.55	3.25
42	3.8	4	4.1	2.6	3.3
44	3.9	4.1	4.2	2.7	3.4
46	4	4.25	4.3	2.8	3.5
48	4.25	4.5	4.4	2.9	3.6
50	4.5	4.6	4.5	3	3.7
52	4.75	4.7	4.6	3.25	3.8
54	4.9	4.8	4.7	3.5	3.9
56	5	4.9	4.8	3.75	4
58	5.15	5	4.9	3.95	4.25
60	5.25	5.1	4.95	4	4.5
62	5.35	5.2	5	4.15	4.75
64	5.4	5.25	5.1	4.2	5
66	5.42	5.3	5.15	4.3	5.1
68	**5.44**	5.35	5.25	4.35	5.2
70		**5.41**	5.35	4.4	5.3
72			**5.39**	4.5	**5.38**
74				4.6	

Table 10: Load Deflection for M40 SFRSCC with 30% GGBFS and a/d-=3.7

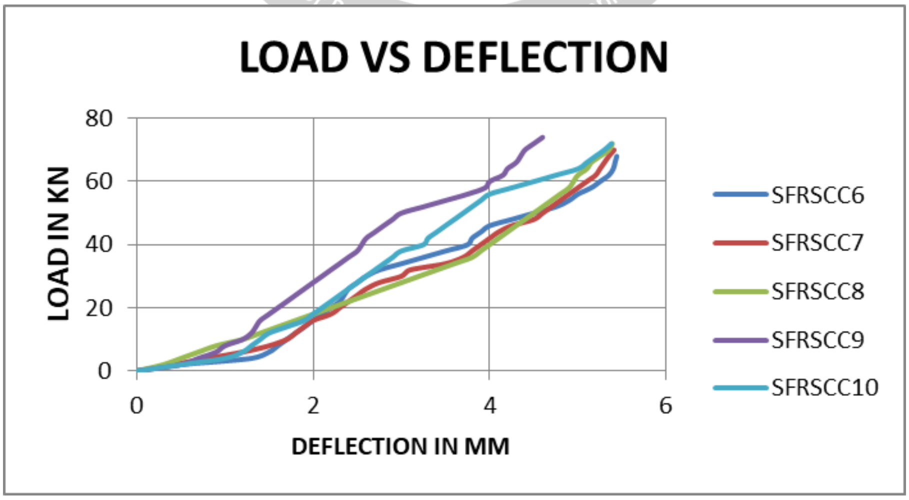

Figure 4: Load Deflection Curve for M40 SFRSCC with 30% GGBFS and a/d-=3.7

Beam No	Mix Designation	First Crack Load in Kn	Deflection In mm	Ultimate Crack Load in Kn	Ultimate Deflection in mm
1	SFRSCC1	24	2.4	66	5.25

 DOI : 10.35291/2454-9150.2024.0365

2	SFRSCC2	26	3.3	68	5.2
3	SFRSCC3	26	3.4	70	5.15
4	**SFRSCC4**	**30**	**1.7**	**74**	**4.15**
5	SFRSCC5	28	1.6	72	5.37
6	SFRSCC6	26	2.4	68	5.44
7	SFRSCC7	28	2.75	70	5.41
8	SFRSCC8	28	3.00	72	5.39
9	**SFRSCC9**	**30**	**2.1**	**74**	**4.6**
10	SFRSCC10	32	2.7	72	5.38

Table 11: Crack Propagation for Case 1 : (a/d=3.7)

Remarks: It is evident from the table 11, that as the steel fibre content in the mix increases load carrying capability of the beam also increases upto 1.5% addition, however at 2% addition of steel fibres the capacity decreases mix M4 with 20% fly ash and 1.5% steel fibres and mix M9 with 30% GGBFS and 1.5% steel fibres carries the maximum load of 74 Kn. However the deflection in mix M4 is 4.15 mm which is less the deflection of mix M9.

LOAD IN KN	**DEFLECTION IN MM**				
	SFRSCC11	**SFRSCC12**	**SFRSCC13**	**SFRSCC14**	**SFRSCC15**
0	**0**	**0**	**0**	**0**	**0**
2	0.3	0.5	0.7	0.2	0.5
4	0.7	0.9	0.9	0.4	0.8
6	0.9	1.2	2.1	1.5	1.2
8	1.3	2.5	2.5	2	1.5
10	1.4	3.4	2.8	2.2	2
12	1.5	3.6	3	2.4	2.4
14	1.6	3.8	3.1	2.6	2.6
16	1.7	3.9	3.2	2.8	2.8
18	1.8	4	3.3	2.9	2.9
20	1.9	4.2	3.4	3	3
22	2	4.3	3.5	3.2	3.2
24	2.25	4.4	3.6	3.3	3.4
26	2.5	4.5	3.8	3.4	3.5
28	2.75	4.6	3.9	3.5	3.6
30	2.95	4.7	4	3.6	3.7

 DOI : 10.35291/2454-9150.2024.0365

32	3	4.8	4.1	3.65	3.9
34	3.25	4.9	4.2	3.7	4
36	3.5	5	4.3	3.8	4.2
38	3.6	5.1	4.4	3.9	4.4
40	3.7	5.25	4.5	4	4.6
42	3.8	5.3	4.6	4.2	4.8
44	3.9	5.4	4.7	4.3	4.9
46	4	5.5	4.85	4.4	5
48	4.5	5.65	4.9	4.6	5.2
50	4.75	5.7	5	4.7	5.3
52	5	5.75	5.25	4.8	5.5
54	5.25	5.85	5.3	4.9	5.6
56	5.5	5.9	5.4	5	5.7
58	5.75	6	5.4	5.1	5.8
60	5.95	6.1	5.5	5.2	5.9
62	**5.97**	**6.18**	5.6	5.3	6
64			5.7	5.35	6.1
66			**5.8**	5.4	**6.3**
68				**5.5**	

Table 12: Load Deflection for M40 SFRSCC with 20% FLY ASH and a/d-=3.8

 DOI : 10.35291/2454-9150.2024.0365

ISSN : 2454-9150 Vol-10, Issue-07, Oct 2024

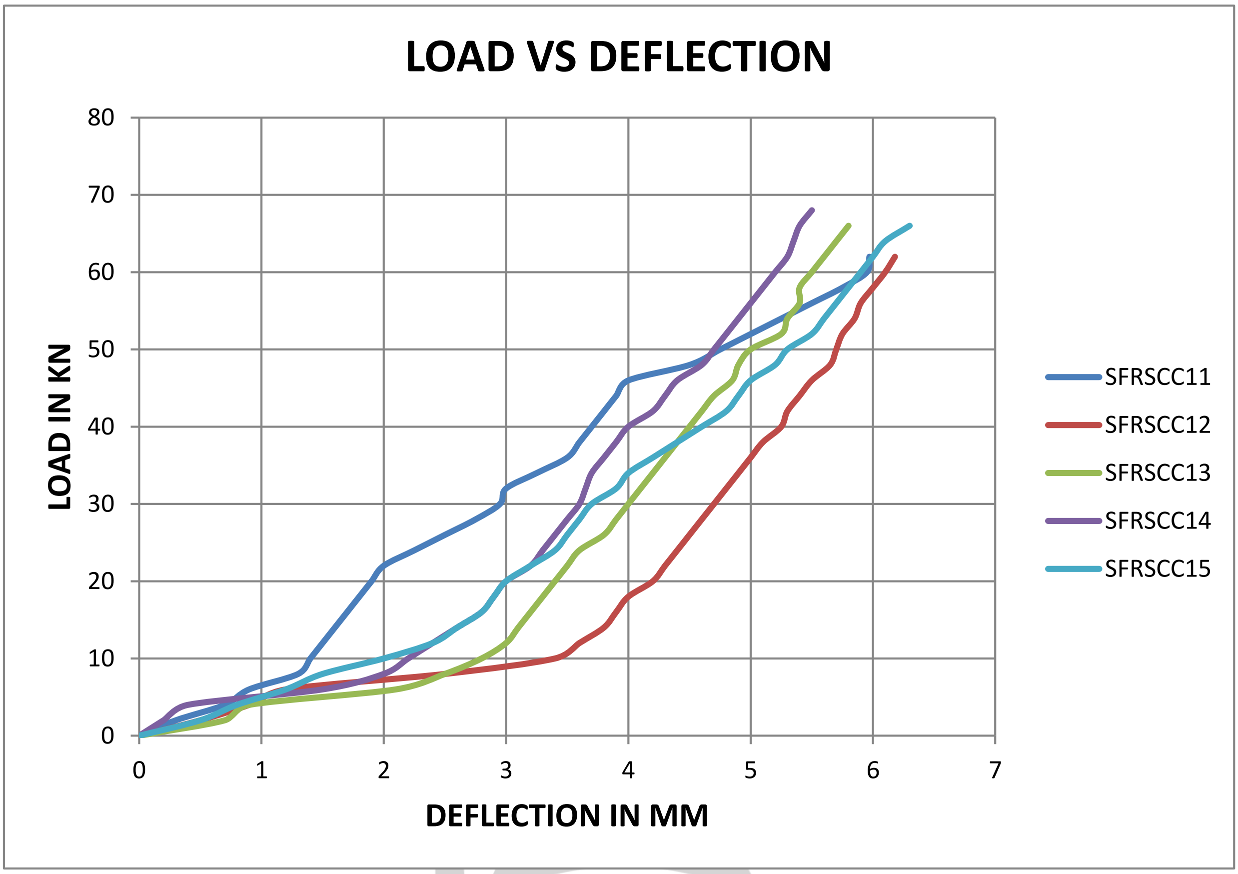

Figure 5: Load Deflection Curve for M40 SFRSCC with 20% FLY ASH and a/d-=3.8

LOAD IN KN	DEFLECTION IN MM				
	SFRSCC16	SFRSCC17	SFRSCC18	SFRSCC19	SFRSCC20
0	0	0	0	0	0
2	0.5	0.6	0.8	0.3	1.3
4	0.9	1	1.3	0.7	1.5
6	1.3	1.5	1.6	1.4	1.7
8	1.5	1.7	2.2	1.7	1.9
10	1.8	1.9	2.5	1.8	2
12	2	2.2	2.6	2.5	2.1
14	2.2	2.7	2.65	2.7	2.2
16	2.8	2.9	2.7	2.9	2.3
18	3	3	2.8	3	2.6
20	3.2	3.4	2.9	3.2	2.8
22	3.6	3.5	3	3.4	2.9
24	3.8	3.7	3.2	3.5	3

 DOI : 10.35291/2454-9150.2024.0365

26	4	3.9	3.4	3.6	3.3
28	4.2	4	3.6	3.7	3.5
30	4.5	4.1	3.8	3.9	3.7
32	4.7	4.3	3.9	4	3.9
34	4.8	4.4	4	4.1	4.1
36	5	4.5	4.3	4.3	4.3
38	5.2	4.6	4.5	4.4	4.5
40	5.4	4.7	4.6	4.5	4.7
42	5.5	4.8	4.7	4.6	4.9
44	5.6	4.9	4.9	4.65	5
46	5.7	5	5	4.7	5.2
48	5.85	5.3	5.1	4.8	5.3
50	5.9	5.5	5.3	4.9	5.4
52	6	5.7	5.4	5	5.6
54	6.1	5.9	5.5	5.1	5.8
56	6.25	6	5.7	5.2	5.9
58	6.4	6.2	5.9	5.3	6
60	6.5	6.4	6	5.4	6.1
62	**6.6**	**6.8**	6.1	5.5	6.2
64			6.3	5.6	6.3
66			**6.6**	5.7	**6.4**
68				**5.8**	

Table 13: Load Deflection for M40 SFRSCC with 30% GGBFS and a/d-=3.8

 DOI : 10.35291/2454-9150.2024.0365

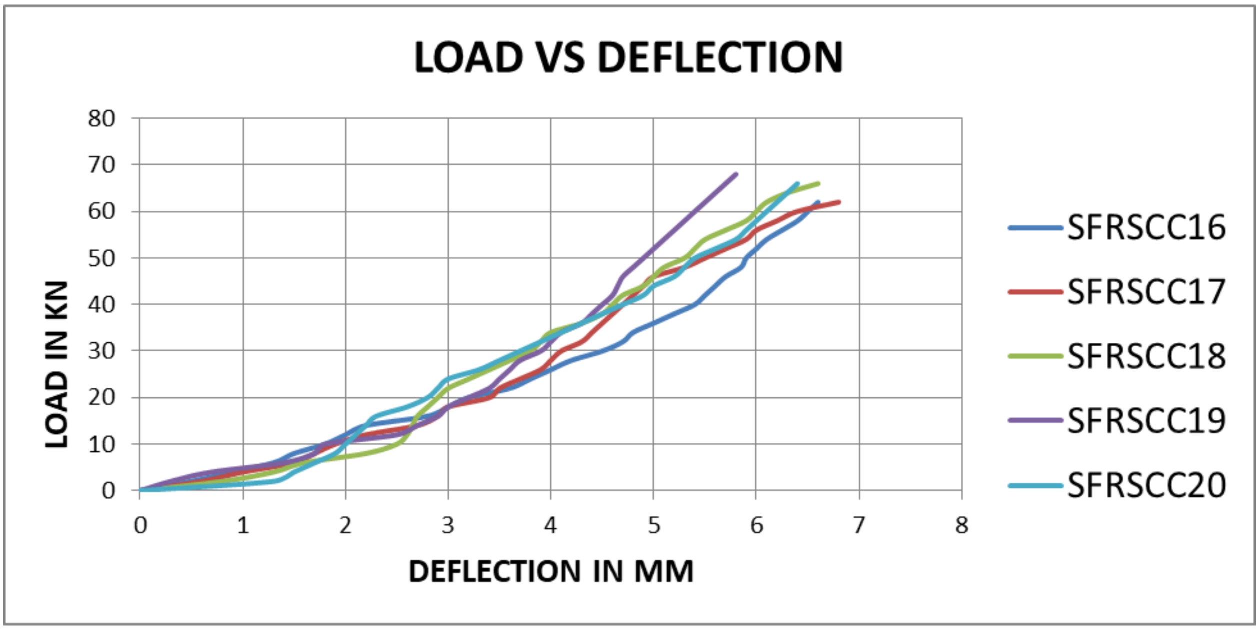

Figure 6: Load Deflection Curve for M40 SFRSCC with 30% GGBFS and a/d=3.8

Beam No	Mix Designation	First Crack Load in Kn	Deflection in mm	Ultimate Crack Load in Kn	Ultimate Deflection in mm
11	SFRSCC11	24	2.25	62	5.97
12	SFRSCC12	28	4.6	62	6.18
13	SFRSCC13	30	4.0	66	5.8
14	**SFRSCC14**	**28**	**3.5**	**68**	**5.5**
15	SFRSCC15	30	3.7	66	6.3
16	SFRSCC16	32	4.7	62	6.6
17	SFRSCC17	32	4.3	62	6.8
18	SFRSCC18	34	4.1	66	6.6
19	**SFRSCC19**	**30**	**3.9**	**68**	**5.8**
20	SFRSCC20	32	4.1	66	6.4

Table 14: Crack Propagation for Case 1 : (a/d=3.8)

Remarks: It is evident from the table 6, that as the steel fibre content in the mix increases load carrying capability of the beam also increases upto 1.5% addition, however at 2% addition of steel fibres the capacity decreases mix M14 with 20% fly ash and 1.5% steel fibres and mix M19 with 30% GGBFS and 1.5% steel fibres carries the maximum load of 68 Kn. However the deflection in mix M14 is 5.5 mm which is less the deflection of mix M19.

5.2.2 Calculation of Experimental Short Term Deflection (ESTD) , Total Experimental deflection (TED) and Total Theoretical Deflection (TTD)

Beam No	Experimental Short Term Deflection (ESTD) in mm	Deflection due to shrinkage	Deflection due to creep	Total Experimental Deflection (TED) in mm	Total Theoretical Deflection (TTD) in mm	Ratio of TED/TTD
1.	5.25	0.235	2.78	8.265	6.27	1.33
2.	5.2	0.235	2.98	8.415	6.27	1.34
3.	5.15	0.235	3.2	8.585	6.27	1.37
4.	4.15	0.235	4.08	8.465	6.27	1.35
5.	5.37	0.235	3.27	8.875	6.27	1.42
6.	5.44	0.235	2.86	8.535	6.27	1.36
7.	5.41	0.235	3.07	8.715	6.27	1.39
8.	5.39	0.235	3.27	8.895	6.27	1.41

 DOI : 10.35291/2454-9150.2024.0365

ISSN : 2454-9150 Vol-10, Issue-07, Oct 2024

9.	4.6	0.235	3.85	8.685	6.27	1.39
10.	5.38	0.235	3.27	8.885	6.27	1.42
11.	5.97	0.235	2.09	8.295	6.345	1.31
12.	6.18	0.235	1.98	8.395	6.345	1.32
13.	5.8	0.235	2.55	8.585	6.345	1.35
14.	5.5	0.235	2.91	8.645	6.345	1.36
15.	6.3	0.235	2.31	8.845	6.345	1.39
16.	6.6	0.235	1.77	8.605	6.345	1.36
17.	6.8	0.235	1.67	8.705	6.345	1.37
18.	6.6	0.235	2.15	8.985	6.345	1.41
19.	5.8	0.235	2.75	8.785	6.345	1.38
20.	6.4	0.235	2.25	8.885	6.345	1.39

Table 15: Ratio of total experimental deflection to total theoretical deflection

Remarks: As per the above given outcomes it is noted that, mix M5 with 20% fly ash and 2% steel fibres and mix M8 with 30% GGBFS and 2% steel fibres and a/d=3.7 has the maximum ratio of 1.42 of total experimental deflection to total theoretical deflection which indicates load carrying capacity of beam-5 and beam-10 is amplified by more than 40% by addition of fly ash, GGBFS & steel fibres.

5.2.3 Calculation of Short Term Deflection (STD) and Long Term Deflection (LTD) in mm by ETABS

Beam No	Ec for Concrete	Short Term Deflection (STD) in mm by ETABS	Long Term Deflection (LTD) in mm by ETABS
1	41918.2	5.64	7.2
2	43603.7	5.14	7.5
3	45322.0	5.53	7.77
4	59456.8	4.46	7.98
5	44707.1	5.77	7.35
6	41680.0	5.85	8.21
7	43143.8	5.81	8.16
8	44541.2	5.79	8.12
9	53640.4	4.94	8.2
10	44624.0	5.78	8.11
11	35072.3	6.4	8.17
12	33880.6	6.62	8.29
13	38429.4	6.22	8.57
14	41753.6	5.89	8.28
15	35379.4	6.75	8.75
16	31724.5	6.43	8.21
17	30791.4	6.87	8.6
18	33771.3	6.8	8.85
19	39594.0	6.09	8.56

 DOI : 10.35291/2454-9150.2024.0365

20	34826.6	6.23	8.76

Table 16: Short term & Long term deflection by ETABS

5.2.4 Comparison of Short Term Deflection (STD) and Long Term Deflection (LTD) by ETABS with experimental values

Beam No	Experimental short term deflection in mm	STD by ETABS in mm	Experimental long term deflection in mm	LTD by ETABS in mm
1	5.25	5.64	8.265	7.2
2	5.2	5.14	8.415	7.5
3	5.15	5.53	8.585	7.77
4	4.15	4.46	8.465	7.98
5	5.37	5.77	8.875	7.35
6	5.44	5.85	8.535	8.21
7	5.41	5.81	8.715	8.16
8	5.39	5.79	8.895	8.12
9	4.6	4.94	8.685	8.2
10	5.38	5.78	8.885	8.11
11	5.97	6.4	8.295	8.17
12	6.18	6.62	8.395	8.29
13	5.8	6.22	8.585	8.57
14	5.5	5.89	8.645	8.28
15	6.3	6.75	8.845	8.75
16	6.6	6.43	8.605	8.21
17	6.8	6.87	8.705	8.6
18	6.6	6.8	8.985	8.85
19	5.8	6.09	8.785	8.56
20	6.4	6.23	8.885	8.76

Table 17: Comparison of Experimental short term deflection & long term deflection with ETABS

Remarks: It is observed that the results obtained from experimental work and ETABS is almost same with slight variation. However it's observed as outcomes of short term deflection obtained by ETABS are higher compared to experimental results. But the long term deflection of ETABS is less while comparing with investigational long term deflections

VI. CONCLUSIONS

1. Fresh concrete takes longer to flow when volume percentage & steel fibre shapes have a hooked end .It was noticed as shear span to depth ratio increases load carrying capacity of beams decreases and simultaneously the deflection in the beam increases.
2. As the a/d ratio increases from 3.7 to 3.8 load carrying capacity of beams decreases from 74 Kn to 62 Kn
3. It has been shown that an increase in volume percentage of steel fibres results in significant rise into flexural strength of SFRSCC; We find that a volume proportion of 1.50% works well.
4. Mix SFRSCC9 & SFRSCC19 with -30% GGBFS +1.5% SF was found to be the most adequate mix if the effect of GGBFS is to be studied.
5. Maximum load carrying capacity was achieved for Mix SFRSCC-4 and Mix SFRSCC09 as 74 KN which contains 20% Fly Ash and 30% GGBFS with 1.5% hooked End Steel fibres respectively.
6. For all beam cases, the short-term deflections calculated from experimental work were less than those calculated from ETABS
7. A few observations can be made from the deflection analysis to identify what is critical for controlling deflections in a beam in order to meet the allowable limit. .
8. Increasing compressive strength of concrete or increasing the tensile steel help reduce deflections with increase cracking moment and the effective moment of inertia, respectively.
9. Long-term deflections, however, resulted in the ETABS deflections being less than the experimental deflections.

 DOI : 10.35291/2454-9150.2024.0365

ISSN : 2454-9150 Vol-10, Issue-07, Oct 2024

10. Hence it could be concluded as mix M4 containing 20% Fly Ash and 1.5% hooked End Steel Fibres is the optimum mix for the production of SFRSCC as it gives maximal load carrying capacity at least deflection.
11. By utilising SFRSCC the length and width of cracks is also reduced.
12. Hence it could be concluded as mix M4 which contains 20% fly ash, 1.5% steel fibres and a/d =3.7 which gives minimum deflection and carries maximum load is the optimum SFRSCC mix.

VII.PHOTOGRAPHS

Figure 7: Mesh for Beam casting

Figure 8: Wooden moulds for beam casting

 DOI : 10.35291/2454-9150.2024.0365

ISSN : 2454-9150 Vol-10, Issue-07, Oct 2024

Figure 9: Curing of concrete beams

Figure 10: Beams for testing

 DOI : 10.35291/2454-9150.2024.0365

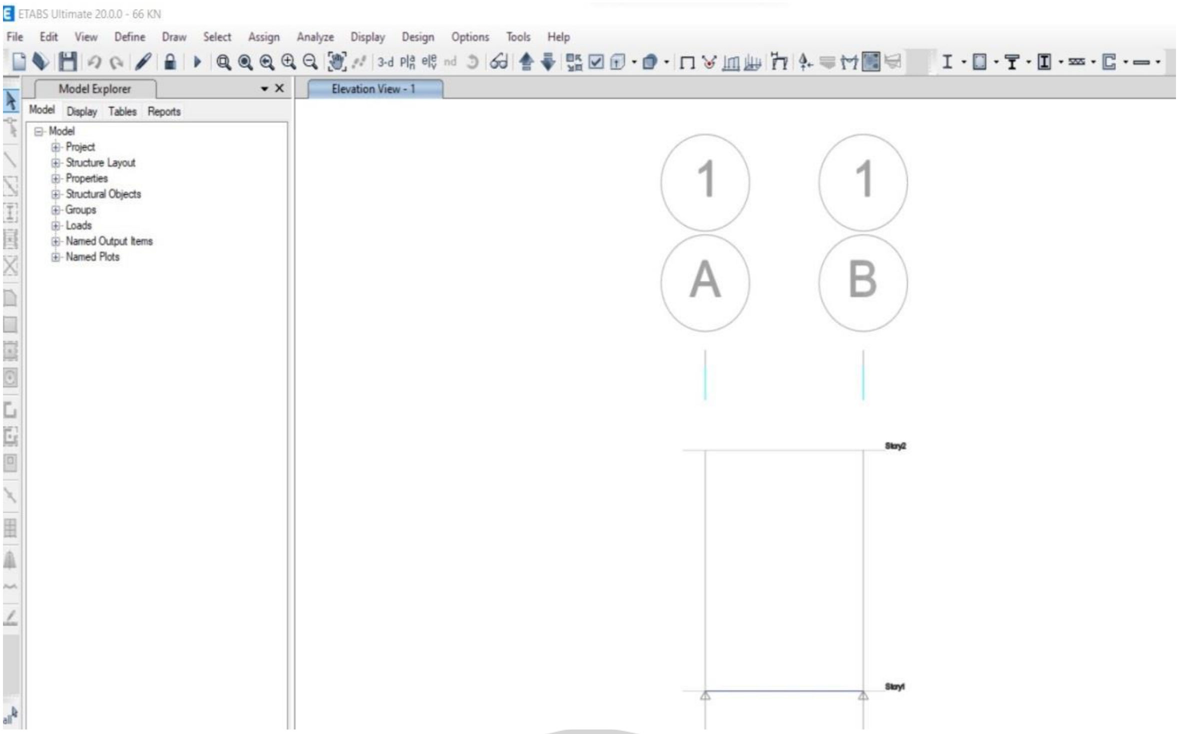

Figure 11: Beam model in ETABS

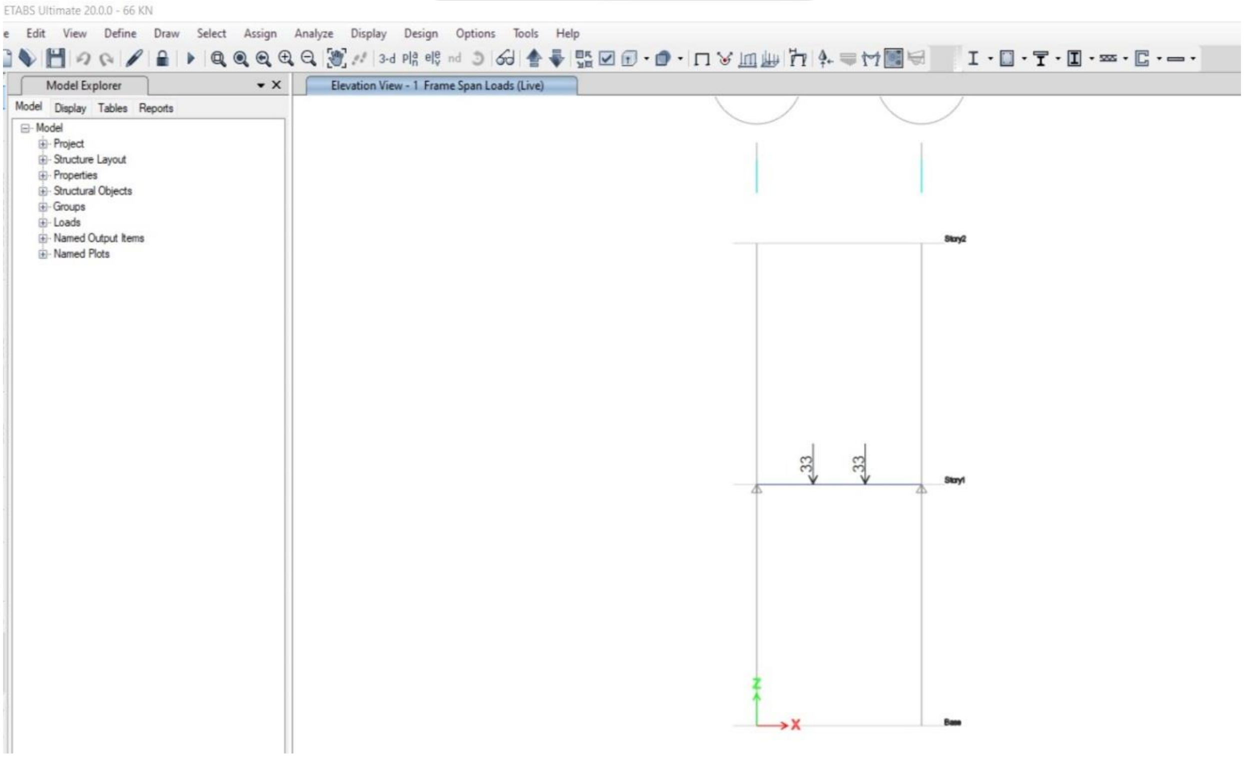

Figure 12: Application of loads

 DOI : 10.35291/2454-9150.2024.0365

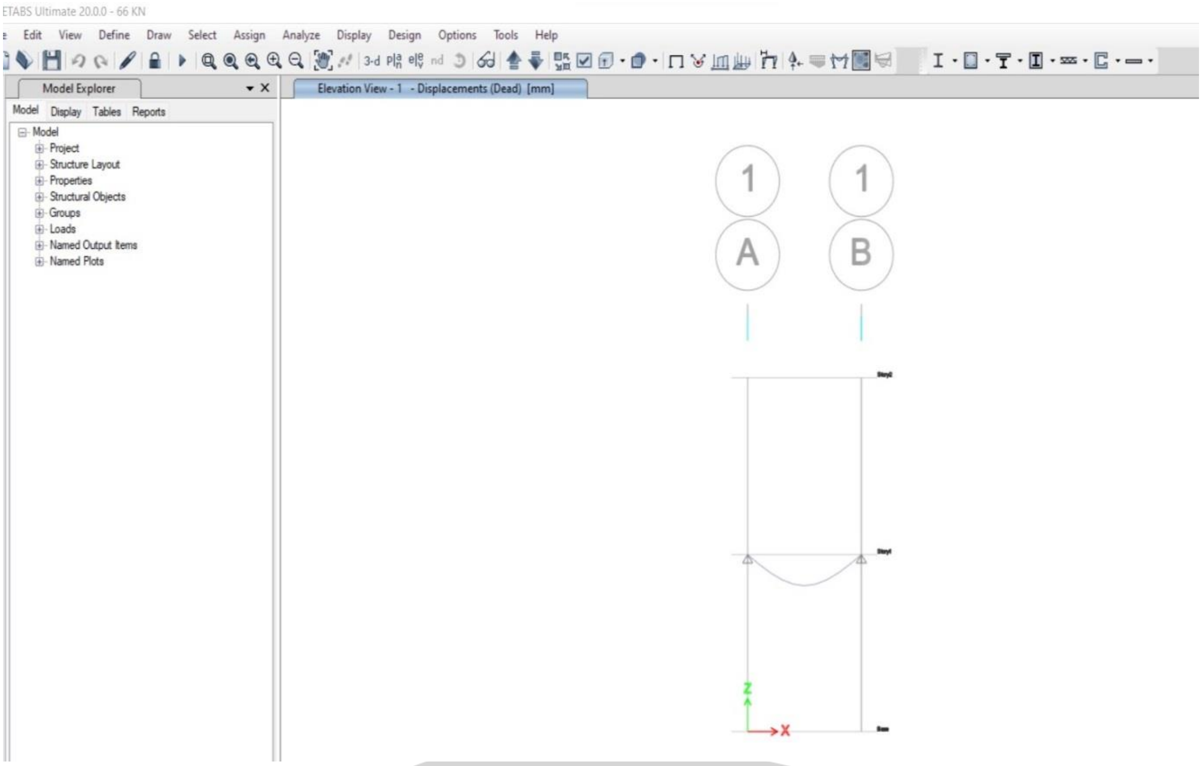

Figure 13: Deflected shape of beams

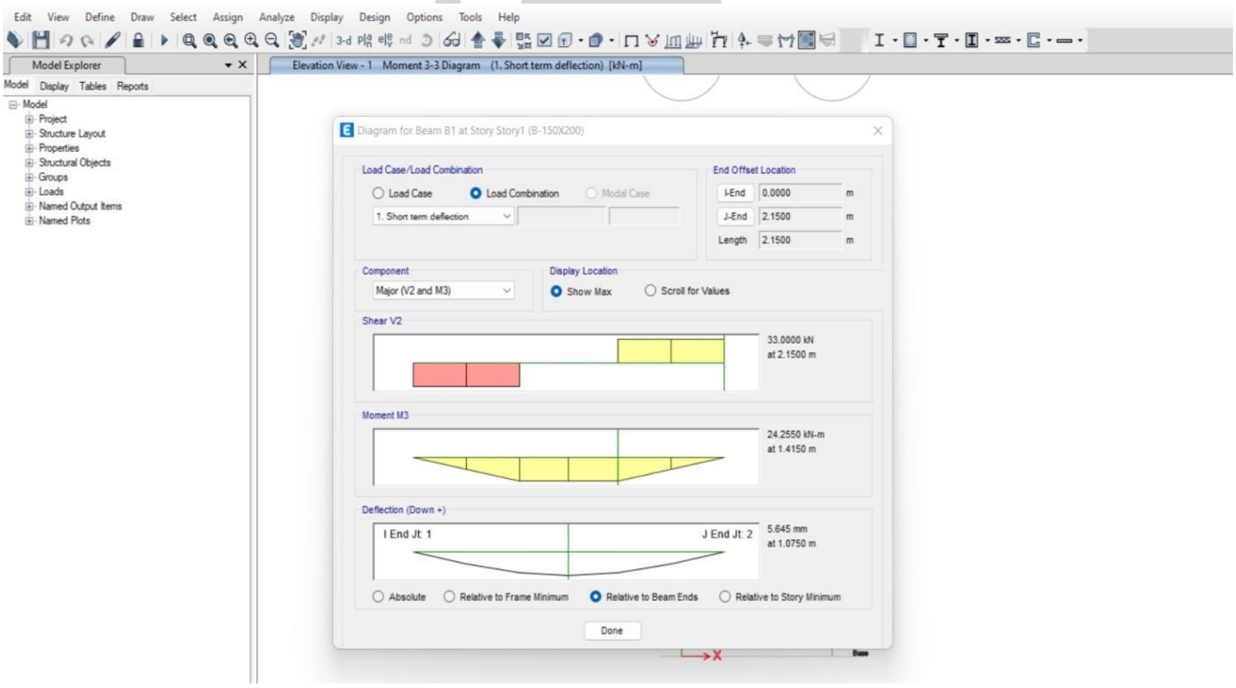

Figure 14: Short term deflection in ETABS

 DOI : 10.35291/2454-9150.2024.0365

ISSN : 2454-9150 Vol-10, Issue-07, Oct 2024

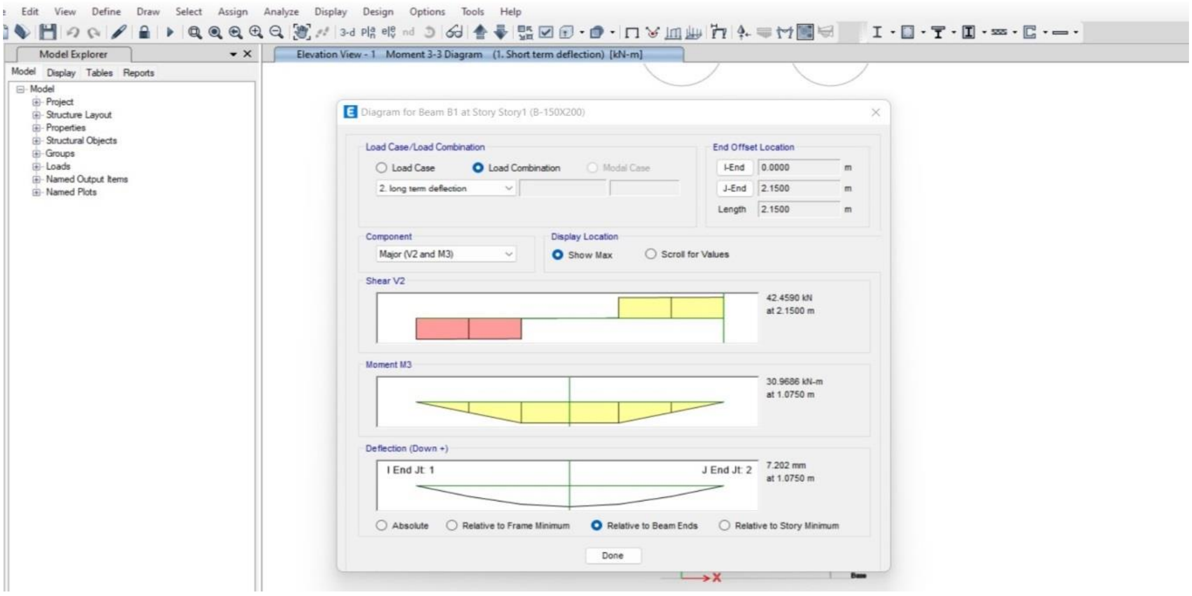

Figure 15: Long term deflection in ETABS

VIII: REFERENCES

[1] Hajime Okamura and Masahiro Ouchi, “Self Compacting Concrete”, Journal of Advanced Concrete Technology Vol. 1, No. 1, April 2003, pp. 5-15

[2] Khayat K. H., “Workability, Testing and Performance of Self Consolidating Concrete”, ACI Materials Journal, Vol. 96, No. 3, May-June 1999, pp.346-354.

[3] EFNARC, “The European Guidelines for Self Compacting Concrete Specification, Production and Use”, May 2005.

[4] Narayanan.R and Darwish.I.Y.S (1987) “Use of steel fibers as shear reinforcement”. ACIStructural Journal. 84: 216–227.

[5] M.S.Shetty. (2005). Concrete Technology, Theory And Practice (2005 Ed.). New Delhi: S. Chand & Company Ltd.

[6] Cucchiara C, Mendola LL, and Papia M. (2004) “Effectiveness of stirrups and steel fibres as shear reinforcement”. Cement Concrete Composites. 26:777–786.

[7] Nan-Su, Kung-Chung, H., & His-Wen, C. (2001). “A simple mix design method for self-compacting concrete. Cement Concrete Research, 31, 1799–1807.

[8] Sahoo, D.R., Bhagat, S. and Reddy, T.C.V., (2016). “Experimental study on shear-span to effective-depth ratio of steel fiber reinforced concrete T-beams”. Materials and Structures, 49(9), pp.3815-3830.

[9] EFNARC. (2002). Specification and Guidelines for Self-Compacting Concrete. Retrieved march 12, 2015, fromefnarc.org

[10] The Concrete Society & BRE. (2005). The Concrete Society, BRE. In R. Day, & I. Holton (Ed.), Technical report No.62 self-compacting. Camberley,UK: Concrete Society, Surrey GU17 9AB, UK

[11] Buquan Miao et.al [2003],A new method for the mix design of medium strength flowing concrete with low cement content, Cement and Concrete Composites, Volume 25, Issue 2, February 2003, Pages 215-222

[12] Gali, S. and Subramaniam, K.V., (2017). “Investigation of the dilatant behavior of cracksin the shear response of steel fiber reinforced concrete beams”. Engineering Structures, 152, pp.832-842.

[13] IS: 12269–1987 “Indian Standard Ordinary Portland Cement, 53 Grade – Specification”, Bureau of Indian Standards, New Delhi.

 DOI : 10.35291/2454-9150.2024.0365