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Experimental Study on Self-Compacting Concrete Mix Design by Using Yucca Zeolite

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Abstract

This report aims to present the experimental investigation on mix proportioning of normal concrete and self-compacting concrete with yucca zeolite. The study area comprises of ordinary portland cement of grade 53,mix proportioning of normal concrete for grade of concrete M40, M30 and M20 whereas mix proportioning for self-compacting concrete for grade of concrete M40, M30 ,M20.The parameters considered are cement content, Water cement ratio i.e. for normal concrete 0.4, 0.42, 0.45 and for self-compacting concrete 0.62, 0.44, 0.43 respectively. To reduce the risk of shrinkage, frost attack and corrosion of concrete, yucca zeolite as a mineral admixture and to increase the bond strength techno plast S 300 as a super plasticizer is added. The responses of material testing, normal concrete tests that includes slump flow test and compressive strength test recorded. Also, tests on self-compacting concrete recorded from slump flow test, J ring test, V funnel test, L box test, U box test, Rheological parameters, Compressive strength at 7 and 28 days. The various properties of SCC are ascertained with the IS code 1199:2018 [part 6] IS code 456:2000, IS code 10262:2019.

Keywords: Self-compacting concrete · Flowability · Workability · Mineral Admixtures · Yucca Zeolite · EFNARC · Flexural Behavior · Compressive Strength · Self-Consolidating Concrete · Super Plasticizer

1. Introduction

SCC has wide application from thin elements to bulk robust structures. Comparing with normal concrete mix design [1] SCC also called as Self-Consolidating Concrete or Rheodynamic concrete is an innovative concrete that does not require vibration for placing and compaction. It is able to flow under its own weight, completely filling formwork and achieving full compaction, even in the presence of congested reinforcement. The principle behind Self-Compacting Concrete is that the settlement of aggregates is related to the viscosity of the fresh concrete. SCC can be produced using the same ingredients as that of normal concrete. However, a closer tolerance is required to ensure strict control of workability characteristics. The proportioning of SCC mix is much more scientific than that of conventional concrete mixes. SCC mix requires high powder content, lesser quantity of coarse aggregate, high range super plasticizer and Viscosity Modifying Agent [VMA] to give stability and fluidity to concrete mix. The workability of SCC is equilibrium of fluidity, deformability, filling ability and resistance to segregation. This equilibrium has to be maintained for a sufficient time period to allow for its transportation, placing and finishing. Combinations of tests are required to characterize the workability properties [2].The various properties of aggregates used that is fine aggregate 10 mm and coarse aggregate of 20 mm are ascertained with the IS code 383:2016 [3]. The parameters considered are cement content, Water cement ratio i.e. for

normal concrete 0.4, 0.42, 0.45 and for self-compacting concrete 0.62, 0.44, 0.43 respectively [1]. To reduce the risk of shrinkage, frost attack and corrosion of concrete, yucca zeolite as a mineral admixture and to increase the bond strength techno plast S 300 as a super plasticizer is added. The responses of material testing, normal concrete tests that includes slump flow test and compressive strength test recorded. Also, tests on self-compacting concrete recorded from slump flow test, J ring test, V funnel test, L box test, U box test, Rheological parameters, Compressive strength at 7 and 28 days. The study area comprises of ordinary portland cement of grade 53,mix proportioning of normal concrete for grade of concrete M40, M30 and M20 whereas mix proportioning for self-compacting concrete for grade of concrete M40, M30 ,M20. Hence, studied the experimental investigation on mix proportioning of normal concrete and self-compacting concrete with yucca zeolite. The fundamental rheological properties and stability of NC and SCC in fresh state where found out with locally available chemical and mineral admixtures related to ACI [4], ASTM [5], BIBM [6], BIS [7], CART [8], EFCA [9], EFNARC [10] specifications.

2. Materials and methods

2.1 Materials

2.1.1 Fine Aggregate

Fine combination typically consists of natural, crushed, or manufactured sand. The crushed aggregate passing through 10 mm sieve was used as fine aggregate in the present study. [Table 1, 2]

2.1.2 Coarse Aggregate

A Machine crushed rock materials used in present work. The coarse aggregate size generally used in the present work is 20mm. [Table 1, 2]

Table 1 Fines modulus of aggregates

Material	Fines modulus
Fine aggregate	6.87
Coarse aggregate	7.4

Table 2 Physical properties of materials

Material	Specific gravity
Cement	3.15
Yucca Zeolite	2.15
Technoplast S 300	1.23
Fly Ash	2.53
River Sand	2.30
Fine aggregate	2.64
Coarse aggregate	2.77

2.1.3 Fly ash

Fly ash is a finely divided residue made from the combustion of pulverized coal that can be used to increase concrete durability and workability, while reducing permeability [Table 2].

2.1.4 Cement

The cement used was Ordinary Portland Cement (OPC) of 53 grade conforming to IS 12269 [4]. The results conformed to the Indian Standard recommendations [Table 2].

2.1.5 River sand

Godavari River sand from Paithan (Maharashtra) confirming Zone-II was used in this experimental study
[Table 2]

3. Specimen preparations

Mix design for controlled normal concrete: M20, M30, M40 AS per IS 456-2000 [1] was adopted. Mix proportions: 1:0.4, 1:0.42, 1:0.42 respectively.
Mix design for controlled self-compacting concrete: M20, M30, M40 AS per IS 10262-2019 [1] was adopted. Mix proportions: 1:0.62, 1:0.44, 1:0.42 respectively.

3.1 Control concrete specimens

Specimens were prepared as cubes and cylinders for M20, M30, M40 grade concrete for control concrete (CC) specimens [Table 8].

4. Testing Program

Workability test for control specimen were carried out by means of J ring test, U box test, V funnel test, L box test or three w/c ratios 0.5, 0.55 and 0.6, likely, out of which 0.55 arrived as optimum. Mechanical properties of SCC were carried out by standard methods according to EFNARC guidelines [Table 3].

Table 3 Tests on cement

SR.NO	DESCRIPTION OF TEST	RESULTS
1	Fineness of cement (residue on IS sieve no 9)	**3.5 %**
2	Specific gravity	**3.15**
3	Standard consistency of cement	**29%**
4	Setting time of cement Initial setting time Final setting time	 **1 hr 35 min** **4 hr 05 min**
5	Soundness test of cement (with Le-Chatelier's mould)	**1.3mm**
6	Compressive strength of cement 7days 28days	 **57.8N/mm2** **79.5N/mm2**

Table 4 Test on sand and aggregate

A] Physical Properties of Fine Aggregate [sand]

SR. NO.	PROPERTY	RESULTS
1	Particle Shape, size	**Round,4.75mm Passing**

2	Fineness modulus	**3.16**
3	Silt Content	**2%**
4	Specific gravity	**2.64**
5	Bulking of sand	**8.03 %**
6	Bulk density	**1793Kg/m^3**
7	Surface moisture	**Nil**

B] Physical Properties of Coarse Aggregate

SR.NO.	**PROPERTY**	**RESULTS**
1	Particle Shape, Size	**Angular,20mm / 10mm Passing**
2	Fineness modulus of 20 mm aggregates	**7.4**
3	Fineness modulus of 10mm aggregates	**6.87**
4	Specific gravity	**2.77**
5	Water absorption	**1.02%**
6	Bulk density of 20 mm aggregates	**1603 Kg/mm^3**
7	Bulk density of 10 mm aggregates	**1585 Kg/mm^3**
8	Surface Moisture	**Nil**

C] Sieve Analysis of Fine Aggregate

SR. NO.	**SIEVE SIZE**	**WEIGHT RETAINED (g)**	**CUMULATIVE WT. RETAINED**	**CUMULATIVE WEIGHT %**	**% PASSING**
1	4.75 mm	0.019	0.019	1.9	98.1
2	2.36 mm	0.123	0.142	14.2	85.8
3	1.18 mm	0.292	0.434	43.4	56.6
4.	600µ	0.252	0.686	68.6	31.4
5	300µ	0.227	0.913	91.3	8.7
6	150µ	0.070	0.983	98.3	1.7
7	pan	0.008	0.991	-	-
Total					317.7

Fineness Modulus [fine aggregate] = 3.17

D] Sieve Analysis of 20mm Coarse Aggregates

SR.NO.	**SIEVE SIZE**	**WEIGHT RETAINED (KG)**	**CUMULATIVE WT. RETAINED**	**% CUMULATIVE WEIGHT**	**% PASSING**
1	40 mm	NIL	NIL	NIL	
2	20 mm	0.065	0.065	1.30	98.70
3	10 mm	4.262	4.327	86.54	13.46
4	4.75 mm	0.673	5.00	100	-
5	2.36 mm	-	-	100	-

6	1.18 mm	-	-	100	-
7	600µ	-	-	100	-
8	300	-	-	100	-
9	150	-	-	100	-
		5.000		687.84	

Fineness Modulus [Coarse aggregate] = 6.87

Table 5 Certificate of analysis

PROPERTIES	**RESULT OBTAINED**
PH of 10% Aqueous Slurry	**8.1**
LOI (%)	**5.3**
CaO (%)	**4.25**
MgO (%)	**0.6**
Fe2O3 (%)	**1.6**
Total SiO2 (%)	**74.3**
Water Absorption (g/100g)	**81.8**
Bulk Density after 100 Drops (g/cc)	**0.6**
Al2O3 (%)	**10.52**
CEC Value	**Above 200 meq/100 gm**

Material: Zeolite (Grade 2)

Analysis of chemical composition of yucca zeolite

Fig 1 Yucca Zeolite Crystals and Yucca zeolite mix with water

1. Zeolites are Hydrated Alumino Silicates of the alkaline and alkaline-earth metals
2. General formula $M^{n+}\ 1/n^{-}{}_{x} \cdot yH_2O$ where M^{n+} 1/n is either a metal ion or H^{+}
3. Physical Properties of yucca zeolite : Surface area = 0.9 g/m3, Density = 0.40 to 0.48 g/ml
4. Asian Paints Smart Care Techno Plast S 300 High performance high range water reducer based on SNF chemistry.

Table 6 Analysis of chemical composition of techno plast s 300

Product Name	**TECHNOPLAST S 300**
Batch No	BM0591
SKU code	6766NH69450

Generic Type	SNF Based
Date of Mfg	24-02-2023
Expiry Date	12 months from the Date of Mfg
Storage Condition	Cool and Dry, Away from Direct Sunlight

Table 7 Analysis of chemical composition of techno plast s 300

SR.NO	TEST	VALUE OBTAINED	IS 9103 LIMITS (RE AFFIRMED 2018)	UOM
1	Appearance	Dark brown liquid	-	No unit
2	Dry material content	43.06 %	± 5% of the value stated by the Manufacturer	% by Mass
3	Relative density	1.234	± 0.02 of the value stated by the Manufacturer	No unit
4	Chloride content	0.0013	Within 10 percent of the value or within 0.2 present whichever as stated by the Manufacturer	% by Mass
5	PH	7.85	Min 6.0	No unit

5. Testing Program on fresh self-compacting concrete

Table 8 different tests on fresh Self-Compacting concrete i.e. J ring, Slump Flow, L Box, U Box, V funnel.

SR NO.	METHOD	PROPERTY
1	Slump Flow Test	Filling Ability
2	T50cm Slump Flow	Filling Ability
3	V-Funnel Test	Filling Ability
4	V-Funnel at T5minuts	Segregation Resistance
5	L-Box Test	Passing Ability

Fig 2 Slump flow & T50 cm test

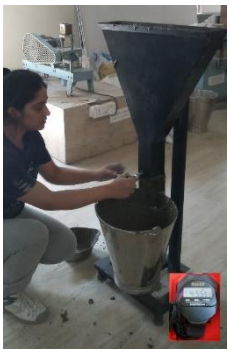


Fig 3 V-Funnel Test

6. Compressive Strength Test

Specimens were prepared by cubes of size 150 mm x 150 mm x 150 mm and the compressive strength at the curing age of 7 and 28 days strength were tested in compression testing machine (CTM) of 1000 kN capacity. Cylinders of size 150 mm diameter and 300 mm height were casted and tested for split tensile strength at the curing age of 7 and 28 days.

Comment for normal concrete CS: 7 days and 28 days compressive strength of concrete is around 65 % and 99 % respectively of characteristic strength of concrete. Accordingly 7 days strength of M20, M30, M40 grade of concrete shall be around 13 N/mm^{2,} 19.5 N/mm^2, 26 N/mm^2 respectively and similarly for 28 days strength shall be 19.8 N/mm^2, 29.7 N/mm^2, $^{39.6}$ N/mm^2. During the experimental study it is observed that the compressive strength is more than the required strength as shown in table below. [Table no. 12, 13, 14]

Comment self-compacting concrete CS: The Increase in Strength is from 16% to 100 % than normal concrete. Addition of fly ash and yucca zeolite, It is observed that the 7 days strength of Self-compacting Concrete of grade M20, M30 and M40 is as expected i.e. more than 65% of Compressive Strength of Concrete and similar results for 28 compressive strength as shown in table below. [Table no. 15, 16, 17]

Fig 4 Compression Testing Machine

7. Flexural Strength Test

Based on the test results obtained through phase-1 investigation, flexural behavior of the self-compacting concrete (SCC) have been aimed and tested off with beam specimens of size 150 x 150 x 750 mm [Table_1 8 , 1 9] for all combinations. Since the earlier strength of the SCC combinations were less than to that of CC, in about 50% average strength, flexural strength of the SCC combinations were tested at 7 and 28 days respectively, which exposed moderate strength that suits to the structural applications. The beams were casted as per the clause 26.5.1.1 of IS: 456-2000 [1] SCC specimens for SCC-1, SCC-2 and SCC-3 combinations. The mix proportion were designed as per IS 10262-2009.

Fig 5 Universal Testing Machine [UTM]

8. Results and discussion

8.1 Tests on fresh properties of self-compacting concrete

Comment: Three mixes as shown in table were prepared to achieve the best possible mix which would fulfil the requirement of technical specifications of SCC with yucca zeolite. Based on work results, fresh properties of SCC for each trial mix with different test methods that is J ring, Slump Flow, L Box, U Box, V funnel. Average mix is considered to be the best possible mix of SCC and can be used as a reference concrete [controlled conditions with varying percentages of yucca zeolite. The percentage of yucca zeolite used were 2%, 4%, 5% respectively. Table shows results of final self-compacting concrete mix proportions.

8.1.1 Test result on SCC M20 grade

Table 9 Experimental Result for SCC M20 of different test i.e. J ring, Slump Flow, L Box, U Box, V funnel.

Tests	Standard Values	Trial 1	Trial 2	Trial 3	Average
J Ring	600-750	640	685	690	**672**
Slump Flow	760-850	760	765	790	**772**
L Box	0.8-1.0	0.85	0.82	0.90	**0.85**
U Box	0-30	26	28	29	**27.66**
V funnel	<8sec	6	7	6.5	**6.5**

8.1.2 Test result on SCC M30 grade

Table 10 Experimental Result for SCC M30 of different test i.e. J ring, Slump Flow, L Box, U Box, V funnel.

Tests	Standard Values	Trial 1	Trial 2	Trial 3	Average
J Ring	600-750	620	670	690	**660**
Slump Flow	760-850	750	765	780	**765**
L Box	0.8-1.0	0.8	0.9	0.85	**0.85**
U Box	0-30	15	25	28	**22.66**
V funnel	<8sec	4.5	5	6.5	**5.33**

8.1.3 Test result on SCC M40 grade

Table 11 Experimental Result for SCC M40 of different test i.e. J ring, Slump Flow, L Box, U Box, V funnel.

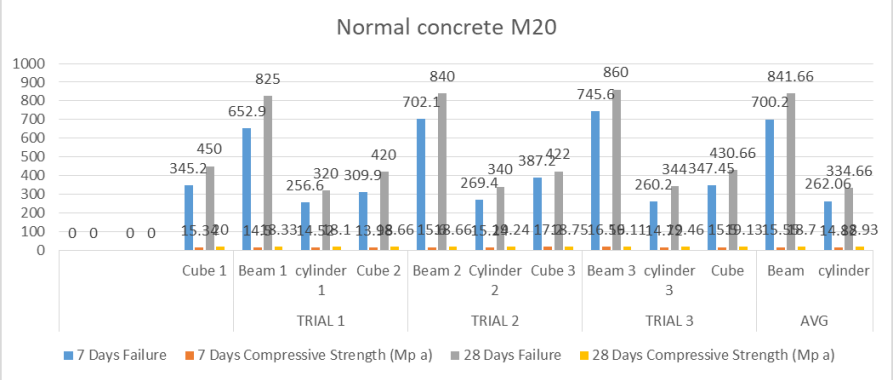
Tests	Standard Values	Trial 1	Trial 2	Trial 3	Average
J Ring	600-750	630	675	680	**662**
Slump Flow	760-850	770	765	785	**773**
L Box	0.8-1.0	0.85	0.8	0.9	**0.85**
U Box	0-30	28	25	26	**26.33**
V funnel	<8sec	5	5.5	6.5	**5.6**

8.2 Compression Strength Test Specimen Results

8.2.1 Compression Strength for Normal concrete M20

Table 12 Experimental result of normal concrete M20

Trials for design mix	Sample No.	7 Days		28 Days	
		Failure Load (KN)	Compressive Strength (Mpa)	Failure Load (KN)	Compressive Strength (Mpa)
TRIAL 1	Cube 1	345.2	15.34	450	20
	Beam 1	652.9	14.50	825	18.33
	cylinder 1	256.6	14.52	320	18.10
TRIAL 2	Cube 2	309.9	13.98	420	18.66
	Beam 2	702.1	15.60	840	18.66
	Cylinder 2	269.4	15.24	340	19.24
TRIAL 3	Cube 3	387.2	17.20	422	18.75
	Beam 3	745.6	16.56	860	19.11
	cylinder 3	260.2	14.72	344	19.46
AVG	**Cube**	**347.45**	**15.50**	**430.66**	**19.13**
	Beam	**700.2**	**15.55**	**841.66**	**18.70**
	cylinder	**262.06**	**14.82**	**334.66**	**18.93**

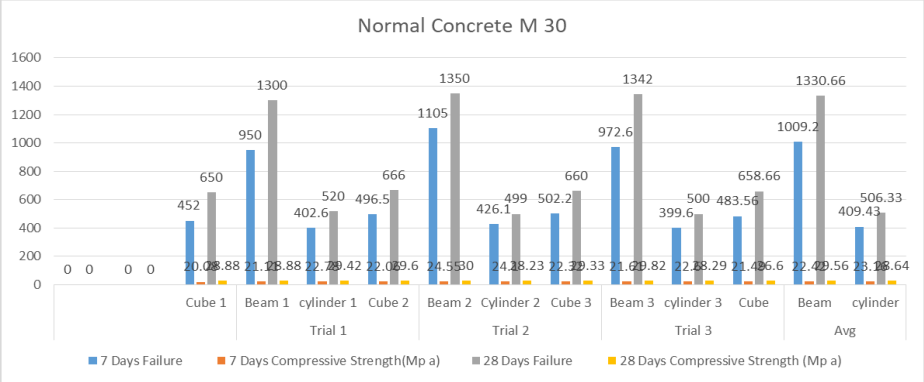


Graph 1 Experimental result of normal concrete M20

8.2.2 Compression Strength for Normal concrete M30

Table 13 Experimental result of normal concrete M30

Trials For design Mix	Sample No.	7 Days		28 Days	
		Failure Load (KN)	Compressive Strength(Mpa)	Failure Load (KN)	Compressive Strength (Mpa)
Trial 1	Cube 1	452	20.08	650	28.88
	Beam 1	950	21.11	1300	28.88
	cylinder 1	402.6	22.78	520	29.42
Trial 2	Cube 2	496.5	22.06	666	29.6
	Beam 2	1105	24.55	1350	30
	Cylinder 2	426.1	24.10	499	28.23
Trial 3	Cube 3	502.2	22.32	660	29.33
	Beam 3	972.6	21.61	1342	29.82
	cylinder 3	399.60	22.60	500	28.29
Avg	**Cube**	**483.56**	**21.49**	**658.66**	**26.60**
	Beam	**1009.2**	**22.42**	**1330.66**	**29.56**
	cylinder	**409.43**	**23.16**	**506.33**	**28.64**

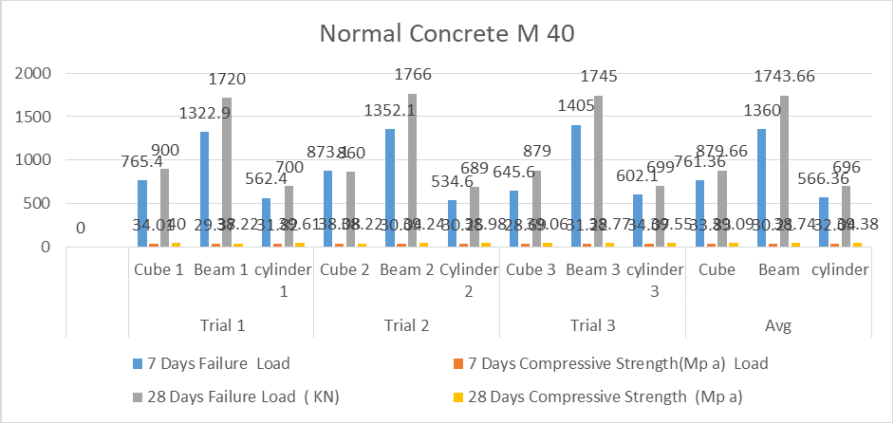


Graph 2 Experimental result of normal concrete M30

8.2.3 Compression Strength for Normal concrete M40

Table 14 Experimental result of normal concrete M40

Trials For Design Mix	Sample No.	7 Days		28 Days	
		Failure Load (KN)	Compressive Strength(Mpa)	Failure Load (KN)	Compressive Strength (Mpa)
Trial 1	Cube 1	765.4	34.01	900	40
	Beam 1	1322.9	29.37	1720	38.22
	cylinder 1	562.4	31.82	700	39.61
Trial 2	Cube 2	873.1	38.08	860	38.22
	Beam 2	1352.1	30.04	1766	39.24
	Cylinder 2	534.6	30.25	689	38.98
Trial 3	Cube 3	645.6	28.69	879	39.06
	Beam 3	1405	31.22	1745	38.77
	cylinder 3	602.1	34.07	699	39.55
Avg	**Cube**	**761.36**	**33.83**	**879.66**	**39.09**
	Beam	**1360**	**30.21**	**1743.66**	**38.74**
	cylinder	**566.36**	**32.04**	**696**	**39.38**

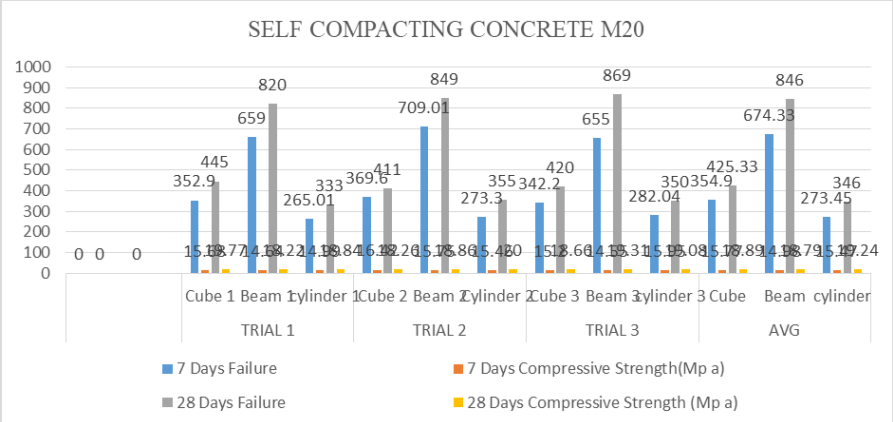


Graph 3 Experimental result of normal concrete M40

8.2.4 Compression strength for self-compacting concrete M20

Table 15 Experimental result of self-compacting concrete M20

Trials For Design Mix	Sample No.	7 Days		28 Days	
		Failure Load (KN)	Compressive Strength(Mpa)	Failure Load (KN)	Compressive Strength (Mpa)
TRIAL 1	Cube 1	352.9	15.68	445	19.77
	Beam 1	659	14.64	820	18.22
	cylinder 1	265.01	14.99	333	18.84
TRIAL 2	Cube 2	369.6	16.42	411	18.26
	Beam 2	709.01	15.75	849	18.86
	Cylinder 2	273.3	15.46	355	20.00
TRIAL 3	Cube 3	342.2	15.20	420	18.66
	Beam 3	655	14.55	869	19.31
	cylinder 3	282.04	15.95	350	19.08
Avg	**Cube**	**354.9**	**15.77**	**425.33**	**18.89**
	Beam	**674.33**	**14.98**	**846**	**18.79**
	cylinder	**273.45**	**15.47**	**346**	**19.24**

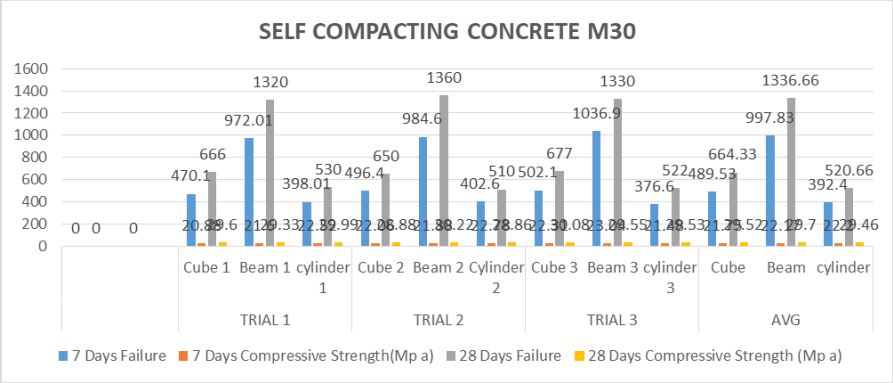


Graph 4 Experimental result of self-compacting concrete M20

8.2.5 Compression strength for self-compacting concrete M30

Table 16 Experimental result of self-compacting concrete M30

Trials For Design Mix	Sample No.	7 Days		28 Days	
		Failure Load (KN)	Compressive Strength(Mpa)	Failure Load (KN)	Compressive Strength (Mpa)
TRIAL 1	Cube 1	470.1	20.88	666	29.6
	Beam 1	972.01	21.6	1320	29.33
	cylinder 1	398.01	22.52	530	29.99
TRIAL 2	Cube 2	496.4	22.06	650	28.88
	Beam 2	984.6	21.88	1360	30.22
	Cylinder 2	402.6	22.78	510	28.86
TRIAL 3	Cube 3	502.1	22.31	677	30.08
	Beam 3	1036.9	23.04	1330	29.55
	cylinder 3	376.6	21.48	522	29.53
Avg	**Cube**	**489.53**	**21.75**	**664.33**	**29.52**
	Beam	**997.83**	**22.17**	**1336.66**	**29.70**
	cylinder	**392.40**	**22.20**	**520.66**	**29.46**

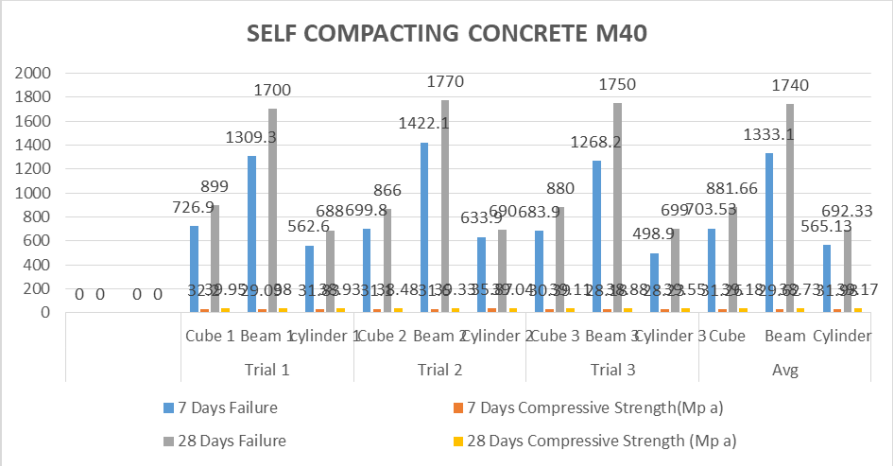


Graph 5 Experimental result of self-compacting concrete M30

8.2.6 Compression strength for self-compacting concrete M40

Table 17 Experimental result of self-compacting concrete M40

Trials For Design Mix	Sample No.	7 Days		28 Days	
		Failure Load (KN)	Compressive Strength(Mpa)	Failure Load (KN)	Compressive Strength (Mpa)
Trial 1	Cube 1	726.9	32.20	899	39.95
	Beam 1	1309.3	29.09	1700	38.00
	cylinder 1	562.6	31.83	688	38.93
Trial 2	Cube 2	699.8	31.10	866	38.48
	Beam 2	1422.1	31.60	1770	39.33
	Cylinder 2	633.9	35.87	690	39.04
Trial 3	Cube 3	683.9	30.39	880	39.11
	Beam 3	1268.2	28.18	1750	38.88
	Cylinder 3	498.9	28.23	699	39.55
Avg	**Cube**	**703.53**	**31.26**	**881.66**	**39.18**
	Beam	**1333.1**	**29.62**	**1740**	**38.73**
	Cylinder	**565.13**	**31.98**	**692.33**	**39.17**



Graph 6 Experimental result of self-compacting concrete M40

8.3 Flexural Strength Test Specimen Results

Fig. 6 Arrangements of loading and specimen for Flexural strength test

Comment for normal concrete: Flexural strength of concrete is always expressed in terms of compressive strength as specified in IS 456 – 2000 and IS 10262 – 2019. It is expressed as $(0.7\sqrt{fck})$ N/mm^2. During the experimental study flexural strength of normal concrete is observe to be greater, The Increase in Strength is from 13 % to 19 % maximum.

Comment for self-compacting concrete: in this experimental study 7 days and 28 days flexural strength of self-compacting concrete is observed to be satisfying the criteria of required strength as per provisions in IS 10262 – 2019. The Increase in Strength is from 11 % to 65 % maximum.

8.3.1 Flexural Strength Tests Results for Normal Concrete M20, M30, M40.

Table 18 Flexural strength tests results for normal concrete M20, M30 and M40

NORMAL CONCRETE				**7 DAYS**		**28 DAYS**	
Sr. No.	**Grade of Concrete**	**Trials for Design Mix**	**Sample No**	**Failure Load [KN]**	**Flexural Strength [Mpa]**	**Failure Load [KN]**	**Flexural Strength [Mpa]**
1	M20	Trial 1	Beam 1	48.20	0.681	96.40	1.362
2		Trial 2	Beam 2	35.40	0.500	70.8	1.000
3		Trial 3	Beam 3	58.10	0.821	116.2	1.642
4		**Avg**	**Beam**	**47.23**	**0.75**	**94.46**	**1.50**

1	M30	Trial 1	Beam 1	81.910	1.158	163.82	2.316
2		Trial 2	Beam 2	91.840	1.299	183.68	2.598
3		Trial 3	Beam 3	95.320	1.348	190.64	2.696
4		**Avg**	**Beam**	**89.69**	**1.26**	**179.38**	**2.52**
1	M40	Trial 1	Beam 1	100.42	1.401	200.84	2.802
2		Trial 2	Beam 2	102.57	1.430	205.14	2.86
3		Trial 3	Beam 3	97.56	1.380	195.12	2.76
4		**Avg**	**Beam**	**100.18**	**1.39**	**200.36**	**2.78**

Table 19 Flexural strength tests results for self-compacting concrete M20, M30 and M40

SELF COMPACTING CONCRETE				7 DAYS		28 DAYS	
Sr. No.	**Grade of Concrete**	**Trials for Design Mix**	**Sample No**	**Failure Load [KN]**	**Flexural Strength [Mpa]**	**Failure Load [KN]**	**Flexural Strength [Mpa]**
1	M20	Trial 1	Beam 1	51.20	0.782	102.4	1.564
2		Trial 2	Beam 2	45.40	0.532	90.8	1.064
3		Trial 3	Beam 3	68.10	0.753	136.2	1.506
4		**Avg**	**Beam**	**54.9**	**0.689**	**109.8**	**1.378**
1	M30	Trial 1	Beam 1	91.810	1.162	183.62	2.324
2		Trial 2	Beam 2	81.8	1.145	163.6	2.29
3		Trial 3	Beam 3	95.352	1.458	190.704	2.916
4		**Avg**	**Beam**	**89.65**	**1.255**	**179.3**	**2.51**
1	M40	Trial 1	Beam 1	100.65	1.501	201.3	3.002
2		Trial 2	Beam 2	101	1.493	202	2.986
3		Trial 3	Beam 3	107.56	1.420	215.12	2.84
4		**Avg**	**Beam**	**103.07**	**1.471**	**206.14**	**2.942**

9.1 Conclusion

1. Addition of fly ash and yucca zeolite increases the workability of concrete.
2. Addition of fly ash in the normal concrete, it is observed that the compression strength is more than 65% for 7 days and 99% for 28 days.
3. In this experimental study, it is observed that addition of fly ash and yucca zeolite helps in increasing the 7 days and 28 days compression strength.
4. The seven days strength of self-compacting concrete for M20, M30, M40 grade are observed to be more than normal concrete as mentioned below:

- Compressive Strength: The Increase in strength is from 16% to 100% maximum.
- Flexural Strength: The Increase in strength is from 20% to 51% maximum

5. The twenty eight days strength of self-compacting concrete for M20, M30, M40 grade are observed to be more than normal concrete as mentioned below:

- Compressive Strength: The Increase in strength is from 22% to 41% maximum.
- Flexural Strength: The Increase in strength is from 11% to 65% maximum.

9.2 Future scope of work

1. The experimentation can be done for various percentages of Fly ash and Yucca Zeolite.
2. The experiment can be extended for Spilt tensile test and Impact test for SCC.
3. To know the exact trend or relationship between SCC and Normal Concrete, more samples need to be casted and tested.
4. The suitability of SCC can be studied for residential projects.

9.3 Compliance with ethical standards

Conflict of statement this is hereby stated that the research paper to be submitted is a unique investigation and purely of my own thesis work.

9.4 References

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