Title: To conduct experiments to evaluate the workability and strength of self-compacting concrete.

Overview: The test was carried out in the Structural engineering laboratory at the **Department of Civil Engineering, IIT Kharagpur, India**. All the experiments were conducted in February 2024 by **Kumar Anjneya**, a research scholar in the Department of Civil Engineering, under the guidance of **Prof. Arghya Deb**.

Objective: To study the role of particle morphology on the rheology and strength of self-compacting fresh concrete

Tests conducted: Sieve analysis, Tests for material characterization of cement, sand and coarse aggregate, Slump test, V-funnel test (& T5 measurement for segregation potential), J-ring, Compression test

1. Material Characterization

1.1 Coarse aggregate

Rounded particles

Table 1: Flakiness and Elongation index of rounded particles

Sieve sizes	Flakiness Index		Elongation Index	
	Sample wt. (g)	wt. of aggregate passing (g)	Sample wt. (g)	wt. of aggregate retained (g)
25-20	3128.5	483.5	2645.0	97
20-16	2506.5	404.5	2102	184
16-12.5	1258.5	32	1226.5	122.5
12.5-10	569	43	526	9
10-6.3	167.5	20	147.5	17
Total wt. (g)	7630	983	6647	429.5
	Flakiness Index		**Elongation Index**	
	12.88		**6.46**	
(Flakiness Index + Elongation Index) < 40% {conforming to IS 383, 2016, Clause 5.3)				
IS: 2386, Part I				

Table 2: Specific gravity of Coarse aggregate (Rounded)

Sl. no.	Specifications	Weight (g)
1	Wt. of sample taken	1000
2	Wt. of vessel + sample + water (A)	4506
3	Wt. of vessel + water (B)	4046.5
4	Wt. of saturated and surface dry aggregate (C)	768.5
5	Wt. of oven dry sample (D)	758
6	Specific gravity	**2.45**
7	Apparent specific gravity	**2.54**
8	Water absorption, % dry wt.	**1.39**
IS: 2386 (PART III)		

Angular particles

Table 3: Flakiness and Elongation index of angular particles

Seive sizes	Flakiness Index		Elongation Index	
	Sample wt. (g)	**wt. of aggregate passing (g)**	**Sample wt. (g)**	**wt. of aggregate retained (g)**
20-16	2090.5	381	1709.5	124.5
16-12.5	1266	70.5	1195.5	177.5
12.5-10	875	106.5	768.5	30.5
10-6.3	201.5	50	151.5	21.5
Total wt. (g)	4433	608	3825	354
	Flakiness Index		**Elongation Index**	
	13.72		**9.25**	
(Flakiness Index + Elongation Index) < 40% {Conforming to IS 383, 2016, Clause 5.3}				
IS: 2386, Part I				

Table 4: Specific gravity of Coarse aggregate (Angular)

Sl. no.	Specifications	Weight (g)
1	Wt. of sample taken	1000
2	Wt. of vessel + sample + water (A)	4677
3	Wt. of vessel + water (B)	4046.5
4	Wt. of saturated and surface dry aggregate (C)	980
5	Wt. of oven dry sample (D)	965
6	Specific gravity	**2.76**
7	Apparent specific gravity	**2.88**
8	Water absorption, % dry wt.	**1.55**
IS: 2386 (PART III)		

Table 5: Angularity of aggregates (Angular and Rounded)

Sl. no.	Specifications	Weight (g)	
		Angular	**Rounded**
1	Wt. of cylinder + sample + water (A)	7120.7	7173
2	Wt. of cylinder + water (B)	5555.5	5555.5
3	Wt. of cylinder (C)	2768.5	2768.5
4	Specific gravity	2.76	2.45
5	Angularity number	**10.42**	**2.49**
IS: 2386, Part I			

Coarse aggregate gradation

Table 6: Proportions of coarse aggregate ($\mathbf{D_{max}}$ **= 20mm**)

Sieve sizes	**Total wt. of sample taken (kg)**	45.95		
	Wt. of the sample retained (kg)	**% retained**	**% Cumulative retained**	**% Passing**
20	0.00	0.00	0.00	100.00
16	9.46	20.59	20.59	79.41
12.5	9.31	20.26	40.85	59.15
10	7.48	16.28	57.13	42.87
6.3	13.07	28.45	85.58	14.42
4.75	6.62	14.42	100.0	0.0

Table 7: Proportions of coarse aggregate ($\mathbf{D_{max}}$ **= 16mm**)

Sieve sizes	**Total wt. of sample taken(kg)**	45.95		
	Wt. of the sample retained (kg)	**% retained**	**% Cumulative retained**	**% Passing**
16	0.00	0.00	0.00	100.00
12.5	11.72	25.51	25.51	74.49
10	9.42	20.50	46.01	53.99
6.3	16.46	35.83	81.84	18.16
4.75	8.34	18.16	100.00	0.00

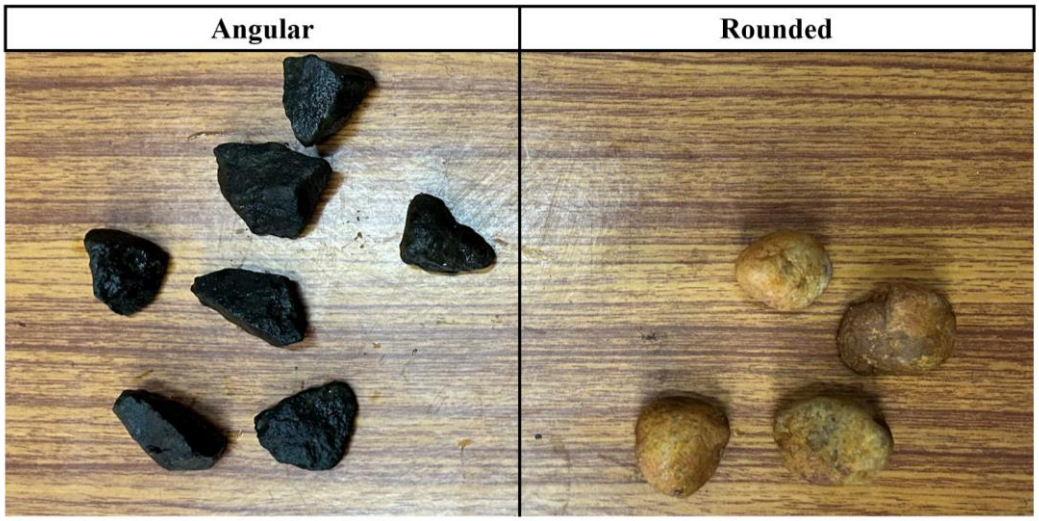

Figure 1: Particles of different morphologies

Figure 2: Angular particles of different size ranges

Figure 3: Rounded particles of different size ranges

1.2 Fine aggregate

Fine aggregate gradation

Table 8: Sieve analysis of sand

Sieve sizes	**Total wt. of sample taken**	1000 g		
	Wt. of the sample retained (g)	**% retained**	**% Cumulative retained**	**% Passing**
4.75 mm	53	5.3	5.3	94.7
2.36 mm	32	3.2	8.5	91.5
1.18 mm	113	11.3	19.8	80.2
600 micron	361	36.1	55.9	44.1
300 micron	359	35.9	91.8	8.2
150 micron	65.5	6.55	98.35	1.65
Pan	16.5	1.65	100	0
Zone II, Confirming to IS 383, 2016, Clause 6.3				
		Fineness modulus	2.7965	

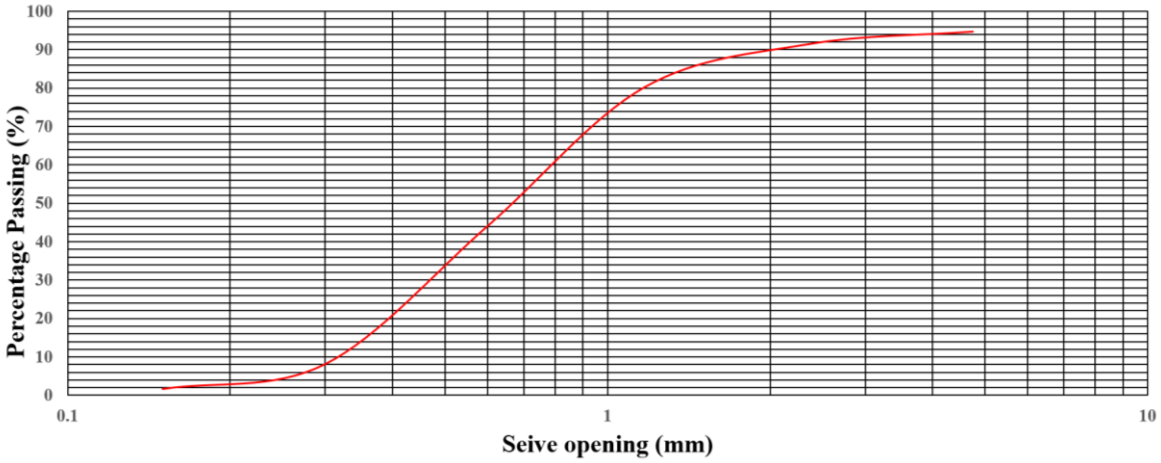

Figure 4: Particle size distribution for fine aggregate

Specific gravity of sand

Table 9: Specific gravity of fine aggregate

Sl. no.	Specifications	Weight (g)
1	Wt. of sample taken	1000
2	Wt. of saturated and surface dry aggregate (C)	500
3	Wt. of pycometer + sample + water (A)	1824.5
4	Wt. of pycometer + water (B)	1513.5
5	Wt. of oven dry sample (D)	494
6	Specific gravity	**2.61**
7	Apparent specific gravity	**2.70**
8	Water absorption, % dry wt.	**1.21**
IS: 2386 (PART III)		

1.3 Cement

Cement: Composite cement 53 grade conforming to IS:455-1989

Initial setting time: (Vicat's apparatus): 48 minutes

Specific surface area

Table 10: Blaine's air permeability test

Sl. No.	Time (s)	Specific surface area (cm^2/g)
1	52.53	3087.55
2	52.38	3083.13
3	52.48	3086.08
	Mean	3085.58

Specific gravity of cement

Table 11: Specific gravity of cement

Sl. no.	Specifications	Weight (g)
1	Wt. of flask, W1	108.1
2	Wt. of flask + cement, W2	163.53
3	Wt. of flask + cement + kerosene, W3	358.55
4	Wt. of flask + kerosene, W4	325
5	Wt. of flask + water, W5	380.77
6	Specific gravity of kerosene	**0.795**
7	Specific gravity of cement	**3.185**
IS: 2720 (PART III)		

1.4 Admixture

A Polycarboxylate-based admixture (PCE) was used to improve the workability of the fresh concrete.

2. Mix design

Table 12: Mix Proportioning (kg/m^3)

Mix	Aggregate	Sand	Cement	Water	Admixture (% of binder)	w/c
I	919	1000	400	200	0.68	0.5

3. Samples

Table 13: Samples for testing

Sl. No.	Designation	Particle shape	Max. aggregate size (D_{max}), mm
I	EXP-A-20	Angular	20
II	EXP-A-16	Angular	16
III	EXP-R-20	Rounded	20
IV	EXP-R-16	Rounded	16

4. Test results

Table 14: Experimental results for fresh concrete samples

Sl. No.	Designation	Slump Flow (mm)	J-ring (mm)	T500 (sec)	V-funnel (sec)	T5 (sec)
I	EXP-A-20	580	515	2.9	11.12	14.35
II	EXP-A-16	560	509	3.2	14.07	16.26
III	EXP-R-20	610	570	2.3	10.21	22.3
IV	EXP-R-16	588	553	2.6	11.01	17.16

T500: time at 500 mm flow, **T5**: time to flow out of V-funnel after 5 mins of standing

Table 15: Compressive strength for fresh concrete samples

Sl. No.	Designation	Compressive strength (MPa) at 28 days
I	EXP-A-20	26
II	EXP-A-16	30
III	EXP-R-20	24.87
IV	EXP-R-16	26.7

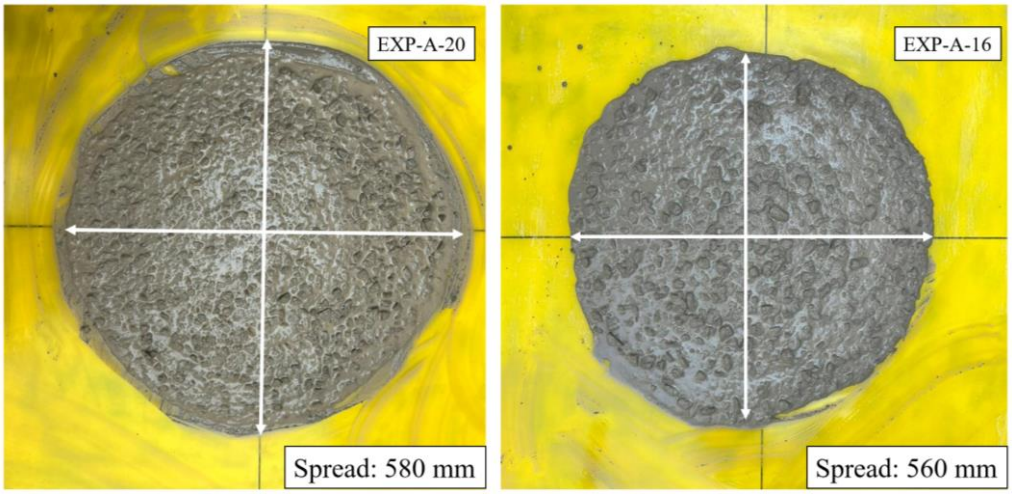

Figure 5: Slump flow for angular particles concrete samples

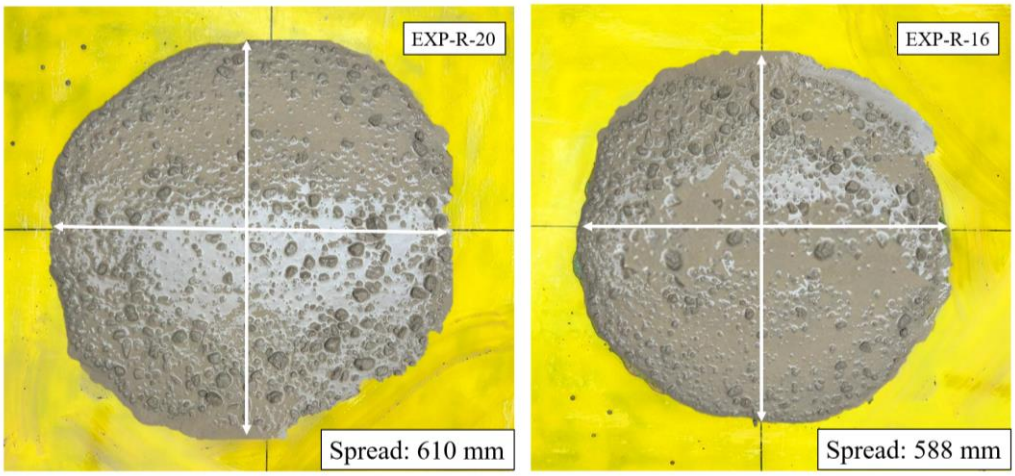

Figure 6: Slump flow for rounded particles concrete samples

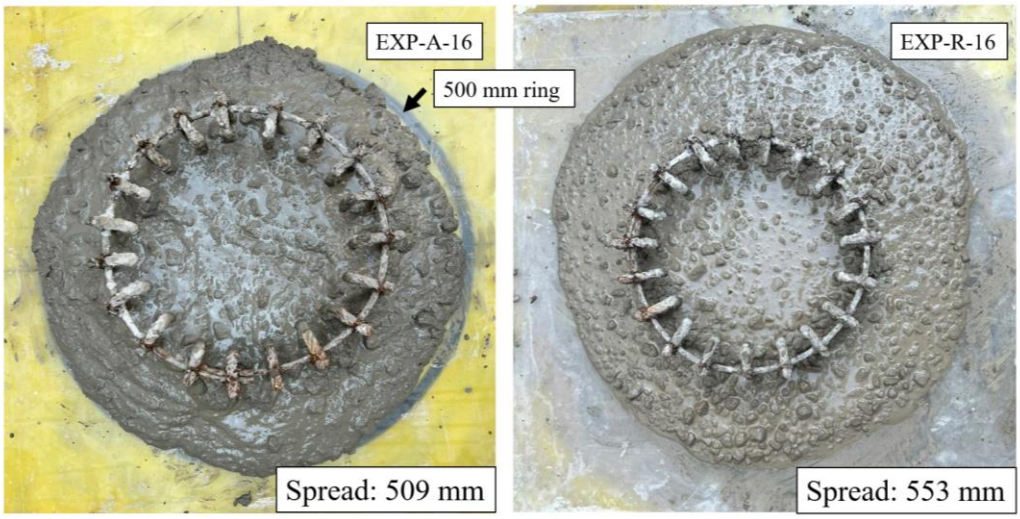

Figure 7: J-ring test for angular and rounded particles concrete

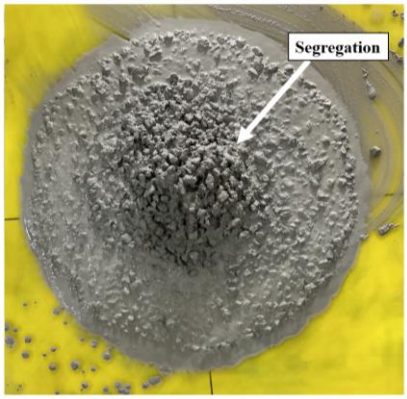

Figure 8: Segregation in angular sample with D_{max} = 25 mm

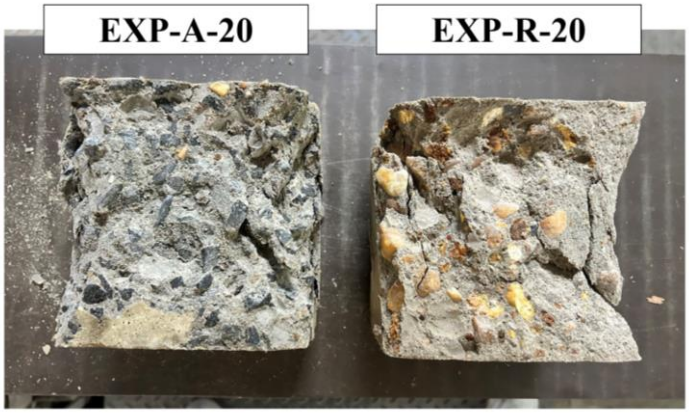

Figure 9: Cracked surface for angular and granular specimen

Figure 10: Crack pattern for EXP-A-16

Conclusion:

Flow was higher in rounded aggregates compared to angular particles. Again, flow increased with an increase in D_{max}. However, with higher $D_{max} > 25$ mm, segregation was noticed with the mentioned mix design.

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1. IS 2386 (PART I): Methods for test for aggregate for concrete, Bureau of Indian Standards, 1963.
2. IS 2386 (PART III): Methods for test for aggregate for concrete, Bureau of Indian Standards, 1963.
3. IS 383: Coarse and fine aggregate for concrete- specifications, Bureau of Indian Standards, 2016.
4. IS 455: Portland slag cement- specification, Bureau of Indian Standards, 1989.
5. IS 2720 (PART III): Methods of test for soil, Bureau of Indian Standards, 1980.