Parametric Study of Concrete Mix Design (M20 And M30) Using 100% Crushed Sand with Special Focus on Silt Content

Garje Amogh Karbhari[1], Gaikwad Bapusaheb Subhas[2], Murdare Chaitanya Vikram[3], Bramhane R.G[4] Gatne D.C[5]

[1,2,3]*Vishwabharati Academy's College of Engineering, Ahilyanagar*

[4,5]*Professor, Vishwabharati Academy's College of Engineering, Ahilyanagar*

***Abstract*—Concrete is one of the most important construction materials, and natural river sand has traditionally been used as fine aggregate in concrete. However, restrictions on river sand extraction, shortage of natural sand, and environmental concerns have created a need for technically suitable alternatives. This study presents a parametric investigation of concrete mix design for M20 and M30 grades using 100% crushed sand, with special emphasis on the effect of silt content. The experimental program included material characterization, concrete mix design, trial mixes, workability measurement, compressive strength testing at 7 and 28 days, and mortar cube strength evaluation. The results indicate that crushed sand concrete can achieve compressive strengths comparable to or higher than natural sand concrete when the mix is properly proportioned. For M20 concrete, optimized crushed sand trial mixes reached 28-day strengths up to 34.70 MPa. For M30 concrete, the best crushed sand trial mix achieved 40.90 MPa. The study also shows that increasing silt content generally reduces compressive strength, while workability tends to increase due to finer particles. The findings support the use of crushed sand as a sustainable replacement for natural sand, provided that silt content and cement consumption are controlled.**

***Index Terms*—Crushed sand; manufactured sand; M20 concrete; M30 concrete; silt content; compressive strength; workability; concrete mix design; sustainable construction.**

I. INTRODUCTION

Concrete is a composite material made from cement, fine aggregate, coarse aggregate, water, and admixtures. It is widely used due to its compressive strength, durability, and ability to be moulded into different shapes. Fine aggregate affects workability, water demand, void content, and the bond between cement paste and aggregate.

Natural river sand is becoming increasingly scarce due to mining restrictions, high transportation cost, and environmental impacts such as riverbed degradation and reduction in groundwater recharge. As a result, crushed sand or manufactured sand has gained attention as an alternative fine aggregate. Crushed sand is produced by crushing hard stone in controlled crushing plants and processing it through screening or washing to achieve required grading and reduce undesirable fines.

Although crushed sand offers several benefits, its angular shape, rough surface texture, higher fines content, and possible silt content can influence water demand and strength development. Therefore, a systematic study is needed to understand its suitability in concrete mixes. This paper presents M20 and M30 grade concrete prepared with 100% crushed sand and evaluates silt content variation from 0% to 20%.

II. OBJECTIVES OF THE STUDY

- To carry out mix design for M20 and M30 concrete using natural sand and crushed sand.
- To compare compressive strength and workability of concrete prepared using natural sand and crushed sand.
- To reduce and optimize cement consumption in crushed sand concrete without compromising strength.

• To study the effect of different silt contents in crushed sand on compressive strength and workability.
• To evaluate the suitability of crushed sand as a sustainable replacement for natural river sand.

III. EXPANDED LITERATURE REVIEW

The use of manufactured sand and quarry dust as fine aggregate has been studied by several researchers due to the increasing shortage of river sand. Ingalkar and Harle investigated replacement of natural sand by crushed sand using materials from different quarry sources. Their study showed that the performance of crushed sand depends significantly on source properties, shape, grading, and fines content.
Mundra, Sindhi, and Chandwani studied crushed rock sand as an economic and ecological alternative to natural sand. Their work considered M25 and M30 grade concretes and evaluated slump, compressive strength, and flexural strength. The study concluded that crushed sand can reduce dependence on natural sand and contribute to ecological balance when combined with appropriate mix design adjustments.
Balamurugan and Perumal examined quarry dust as a replacement for river sand in concrete and showed that quarry dust can be used as a fine aggregate substitute when replacement level and workability are controlled. Balapgol, Kulkarni, and Bajoria evaluated strength and durability of concrete prepared with crushed basalt stone fine aggregate and reported improved compressive and flexural strength compared with conventional concrete.
Khanorkar and co-authors emphasized that artificial sand generally reduces workability because of its angular and rough texture, but this can be managed using suitable plasticizer dosage. Jadhav and Kulkarni studied manufactured sand in cement mortar and found improved mortar strength at appropriate replacement levels. Overall, the literature supports crushed sand as a technically feasible substitute, provided grading, particle shape, water demand, silt content, and mix optimization are controlled.

IV. MATERIALS AND EXPERIMENTAL METHODOLOGY

Pozzolana Portland Cement of ACC brand, locally available natural river sand, crushed sand, 20 mm coarse aggregate, water, and admixture were used. Material properties were determined by specific gravity, fineness modulus, sieve analysis, and jar test for silt content. M20 and M30 concrete mixes were designed using IS 10262:2009 and IS 456:2000. Concrete cubes of size 150 mm x 150 mm x 150 mm were cast, demoulded after 24 hours, cured in water for 28 days, and tested in a compression testing machine. Slump cone tests were performed for workability.

Table 1. Physical properties of aggregate materials

Property	Natural sand	Crushed sand	Coarse agg.
Specific gravity	2.564	2.90	2.80
Fineness modulus	3.75	2.70	-
Silt content	2.61%	5.70%	-

Table 2. Sieve analysis of natural and crushed sand

Sieve	Natural (%)	Crushed (%)	Zone II
4.75 mm	99.00	99.85	90-100
2.36 mm	88.00	77.15	75-100
1.18 mm	60.00	41.25	55-90
600 µm	39.00	22.25	35-59
300 µm	10.00	9.10	8-30
150 µm	3.00	3.05	0-10

4.1 Silt Content and Mortar Testing

To examine the effect of silt content, M20 crushed sand concrete was prepared with the same mix proportion and silt contents of 0%, 5.7%, 10%, 15%, and 20%. Mortar cubes were prepared using crushed sand at water-cement ratios of 0.45, 0.50, and 0.60 while maintaining comparable workability.

V. RESULTS AND DISCUSSION

5.1 M20 Concrete Compressive Strength and Cement Consumption

Table 3. M20 concrete compressive strength results

Mix	Proportion	7-day	28-day
NS design	0.52:1:2.18:3.32	22.74	24.20
NS trial	0.49:1:2.45:3.40	18.94	25.41
CS design	0.48:1:1.98:3.11	8.72	30.81
CS trial 1	0.43:1:1.45:3.13	16.13	33.28
CS trial 2	0.43:1:2.00:3.30	23.40	34.60
CS trial 3	0.43:1:1.95:3.60	22.23	34.70

Table 4. M20 workability and cement consumption

Mix	Workability (mm)	Cement (kg/cum)
NS design	20	330.00
NS trial	22	359.65
CS design	30	364.00
CS trial 1	25	416.50
CS trial 2	20	397.26
CS trial 3	15	382.90

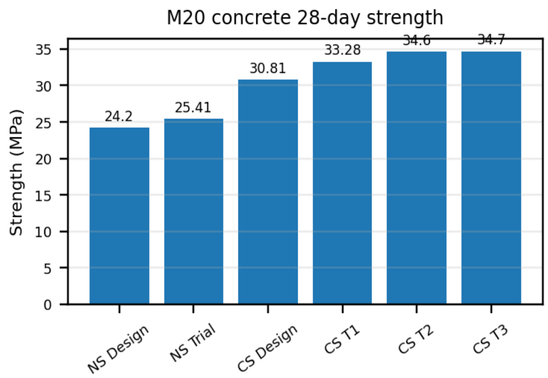

Figure 1. 28-day compressive strength comparison for M20 concrete.

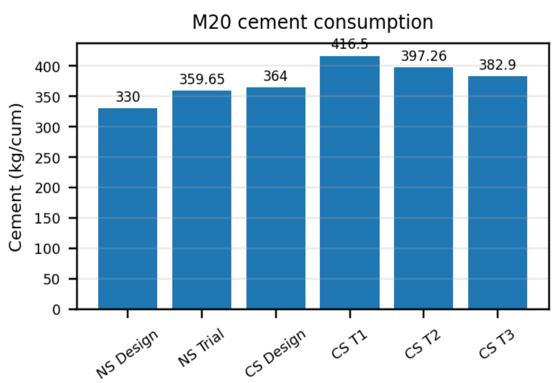

Figure 2. Cement consumption comparison for M20 concrete.

For M20 grade concrete, all crushed sand mixes achieved higher 28-day compressive strength than the natural sand mix design. Crushed sand trial mix 3 reached 34.70 MPa, which was the highest value among M20 mixes. However, cement consumption was higher in crushed sand concrete, confirming the need for optimization when using angular manufactured sand.

5.2 M30 Concrete Compressive Strength and Cement Consumption

Table 5. M30 concrete compressive strength results

Mix	Proportion	7-day	28-day
NS design	0.45:1:1.84:3.23	23.70	26.01
NS trial	0.46:1:1.80:2.75	18.60	30.67
CS design	0.46:1:1.82:2.87	14.40	29.20
CS trial 1	0.42:1:1.30:2.81	17.60	32.40
CS trial 2	0.40:1:1.60:3.00	23.54	40.90
CS trial 3	0.40:1:1.70:3.40	20.93	38.50

Table 6. M30 workability and cement consumption

Mix	Workability (mm)	Cement (kg/cum)
NS design	25	380.00
NS trial	30	423.28
CS design	25	454.50
CS trial 1	15	456.20
CS trial 2	130	449.00
CS trial 3	100	444.40

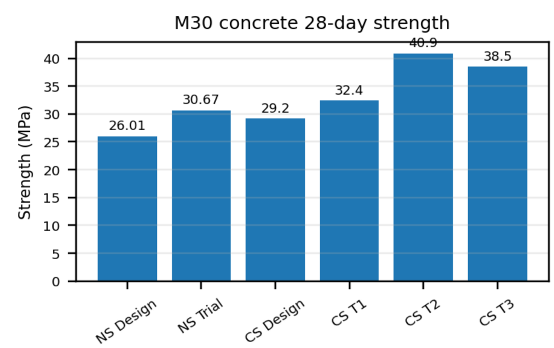

Figure 3. 28-day compressive strength comparison for M30 concrete.

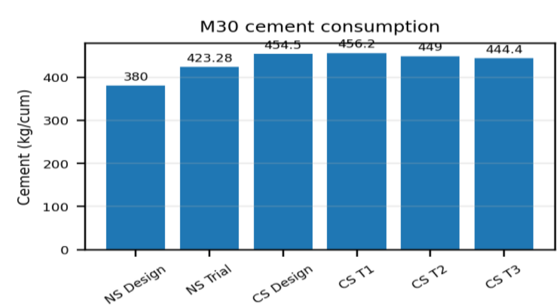

Figure 4. Cement consumption comparison for M30 concrete.

For M30 grade concrete, crushed sand trial mix 2 gave the maximum 28-day strength of 40.90 MPa, followed by trial mix 3 at 38.50 MPa. These results demonstrate that crushed sand concrete can meet and exceed M30 requirements when designed properly. Higher cement content and admixture adjustment contributed to the improved performance.

5.3 Effect of Silt Content

Table 7. Effect of silt content on M20 crushed sand concrete

Silt	Proportion	7-day	28-day	Work.
0%	0.43:1:1.45:3.13	27.32	41.16	22
5.7%	0.43:1:1.45:3.13	16.13	33.28	25
10%	0.43:1:1.45:3.13	24.84	36.14	28
15%	0.43:1:1.45:3.13	23.40	35.70	30
20%	0.43:1:1.45:3.13	23.20	34.00	33

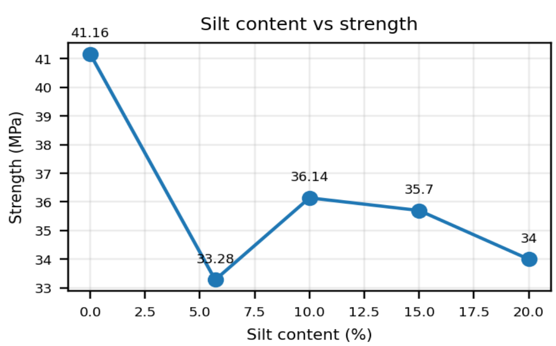

Figure 5. Effect of silt content on 28-day compressive strength.

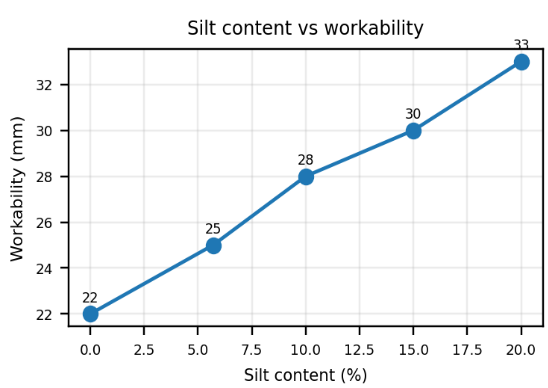

Figure 6. Effect of silt content on workability.

The maximum strength of 41.16 MPa was obtained for concrete with 0% silt. Strength decreased as silt content increased, reaching 34.00 MPa at 20% silt. This reduction is attributed to weaker bonding between cement paste and aggregate particles due to fine silt particles. At the same time, workability increased from 22 mm to 33 mm as silt content increased, showing that finer particles can improve flow but may reduce mechanical performance.

5.4 Mortar Cube Results

Table 8. Mortar cube results using crushed sand

w/c ratio	Cement:FA	28-day strength
0.60	1:3.34	30.03
0.50	1:3.33	32.24
0.45	1:2.21	34.56

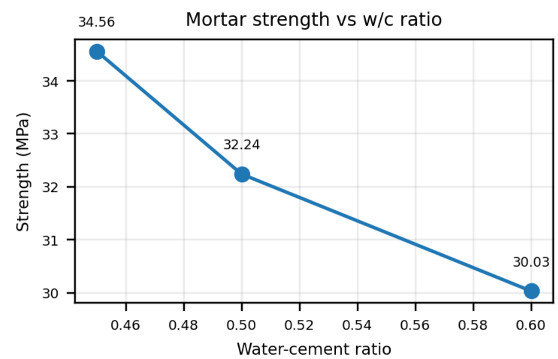

Figure 7. Mortar cube compressive strength at different water-cement ratios.

Mortar cube strength decreased from 34.56 MPa to 30.03 MPa as the water-cement ratio increased from 0.45 to 0.60. This confirms the expected relationship between water-cement ratio and strength. Lower water-cement ratio provides a denser matrix and improved compressive strength.

VI. CONCLUSIONS

- Crushed sand concrete achieved 28-day compressive strengths equal to or higher than natural sand concrete in both M20 and M30 grades.
- For M20 grade concrete, the highest 28-day strength was 34.70 MPa for crushed sand trial mix 3.
- For M30 grade concrete, crushed sand trial mix 2 achieved the highest 28-day strength of 40.90 MPa.

• Cement consumption in crushed sand concrete was generally higher than in natural sand concrete due to angular texture and increased water demand.
• Silt content had a significant influence on strength. The 0% silt mix achieved the highest strength, while higher silt contents reduced compressive strength.
• Workability increased with silt content, but this improvement was accompanied by lower strength.
• Crushed sand is a feasible and sustainable alternative to natural sand when grading, silt content, cement content, and admixture dosage are properly controlled.
• The experimental findings indicate that properly graded crushed sand can be effectively utilized as a sustainable replacement for natural river sand in M20 and M30 concrete without compromising compressive strength requirements.
Limitations of Study: The present investigation focuses primarily on compressive strength, workability, and silt-content effects under laboratory conditions. Durability-related properties such as permeability, sulphate resistance, carbonation resistance, and long-term field performance were not evaluated and may be considered for future research.

VII. FUTURE SCOPE

Further research can focus on optimizing cement consumption in crushed sand concrete, evaluating durability properties such as permeability and sulphate resistance, studying high-strength concrete with manufactured sand, and assessing the combined use of crushed sand with fly ash, GGBS, silica fume, or other supplementary cementitious materials. Field-scale trials may also be conducted to validate laboratory findings under practical construction conditions.

ACKNOWLEDGEMENT

The authors express their sincere gratitude to our HOD Prof. Bramhane R.G., Prof. D. C. Gatne, Department of Civil Engineering, Vishwabharati Academy's College of Engineering, Ahilyanagar, for his valuable guidance, encouragement, and continuous support throughout this research work. The authors also acknowledge the support provided by the faculty members and laboratory staff of the Civil Engineering Department for facilitating the experimental investigations and providing the necessary resources required for successful completion of this study.

REFERENCES

[1] Rameshwar S. Ingalkar and Shrikant M. Harle, “Replacement of Natural Sand by Crushed Sand in Concrete,” 2017.
[2] Sanjay Mundra, P. R. Sindhi and Vinay Chandwani, “Crushed rock sand - An economic and ecological alternative to natural sand to optimize concrete mix,” Elsevier, 2016.
[3] G. Balamurugan and Dr. P. Perumal, “Use of Quarry Dust to Replace Sand in Concrete - An Experimental Study,” International Journal of Scientific and Research Publications, Vol. 3, Issue 12, 2013.
[4] B. Balapgol, S. A. Kulkarni and K. M. Bajoria, “Strength and Durability of Concrete with Crushed Sand,” 27th Conference on Our World in Concrete and Structures, Singapore, 2002.
[5] P. A. Khanorkar, P. M. Aglawe, A. A. Khadse and Dr. P. S. Pajgade, “Replacement of Conventional Sand by Artificial Sand in Concrete,” International Conference on Science and Technology for Sustainable Development, 2016.
[6] Priyanka A. Jadhav and Dilip K. Kulkarni, “Effect of Replacement of Natural Sand by Manufactured Sand on the Properties of Cement Mortar,” International Journal of Civil and Structural Engineering, Vol. 3, No. 3, 2013.
[7] Prof. B. V. V. Venkatarama, “Suitability of Manufactured Sand as Fine Aggregate in Mortars and Concrete,” CSIC Project CP 6597/0505/11-330.
[8] Ganesh V. Tapkire, “Comparative Analysis of River and Crushed Sand,” International Journal of Innovative Research in Science, Engineering and Technology, Vol. 6, Issue 3, 2017.
[9] IS 10262:2009, Indian Standard Concrete Mix Proportioning Guidelines, Bureau of Indian Standards.
[10] IS 456:2000, Indian Standard Plain and Reinforced Concrete - Code of Practice, Bureau of Indian Standards.
[11] IS 383:1970, Indian Standard Specifications for Coarse and Fine Aggregates from Natural Sources for Concrete, Bureau of Indian Standards.
[12] M. S. Shetty, Concrete Technology, S. Chand Publications.