Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 3, No. 3, March : 2024

INFLUENCE OF STONE DUST AND SAND DERIVED GRAVEL ON COMPRESSIVE STRENGTH OF CONCRETE

Mr. Kangkan Das, **Ms. Ritumoni Gogoi**, Dept. of Civil Engineering, CIT Kokrajhar, Assam
Dr. Pranjal Barman Assistant Professor, Dept. of Civil Engineering, CIT Kokrajhar, Assam-783370, India; email-p.barman@cit.ac.in

Abstract
The rapid urbanization triggers the massive use of fine and coarse aggregates in production of concrete. It results in generation of huge quantity of stone dust in the stone quarry and river sand derived gravel which creates environmental concerns. The influence of stone dust and gravel derived from river sand on compressive strength of control concrete containing M20 grade of concrete has been investigated in this study. The sand and aggregate used were collected from the institute campus which was used for the construction of building. The cement used was of Portland Pozzolana Cement (PPC) type. Test cubes were prepared for different percentages of sand and coarse aggregates by replacing it with stone dust (0%, 20%, 40%, 60%, 80 and 100%) and sand derived gravel (0% and 40%) respectively. Concrete with 20% stone dust replacing river sand showed enhanced compressive strength compared to control concrete. It is found that 20% quarry dust and 40% of sand derived gravel can be used as partial replacement materials for fine aggregate and coarse aggregate respectively in concrete.
Keywords: Stone dust, coarse aggregate, compressive strength, concrete.

I. Introduction

The use of stone dust as a replacement for sand in concrete has been the subject of several studies in recent years. Researchers have sought to explore its potential as an alternative material due to concerns over the availability and cost of traditional river sand, as well as environmental considerations. The findings contribute to the body of knowledge surrounding sustainable construction practices and the development of alternative materials in the construction industry. By exploring the potential benefits and limitations of stone dust as a sand replacement, research aim to support the development of more environmentally friendly and cost-effective concrete mixtures while maintaining or improving overall concrete performance. Moreover, utilization of coarse aggregates (gravel) derived from river sand after sieving, has become one of the main goals of this study since it creates environmental issues related to land use for its disposal. The problem associated with depletion of raw materials for production of concrete also draws attention to engineers. Instead of using sand and conventional coarse aggregates, two waste materials – stone dust and river sand derived gravel were used in this study. It is also cost effective.

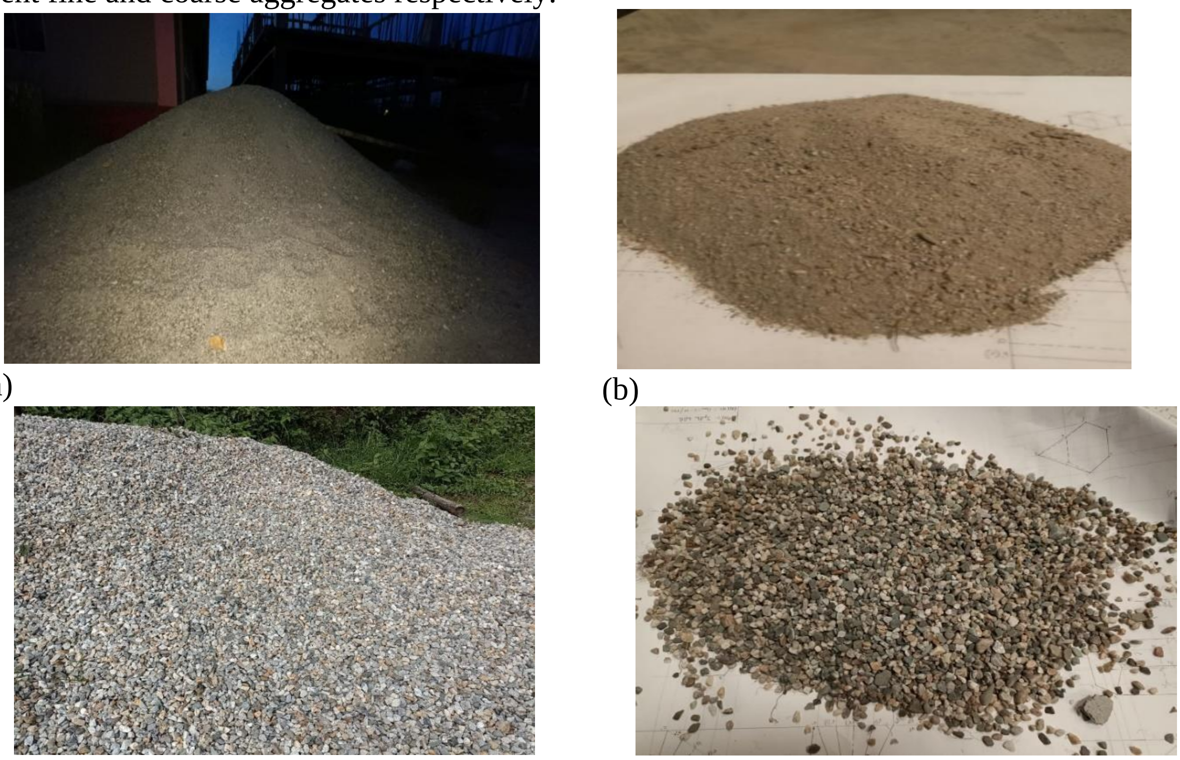
Several studies have been made to find out the usability of stone dust as a replacement of sand in concrete. Nuruzzaman et al. [1] reported that the compressive strength and tensile strength of concrete mixes were found to be maximum at 30% and 20% replacement level of river sand by stone dust in mixes. From the results obtained from the experiments it was found that at all the replacement level compressive strength of concrete containing stone dust was more than that of referral concrete [2,3]. The incorporation of stone quarry dust improved the mechanical and durability properties of concrete [4,5,6]. The influence of quarry stone dust on strength of concrete was also assessed by Venkatesh et al. and Khan and Kumar [7,8]. They reported that the compressive and flexural strength was improved on addition of quarry dust in place of natural sand to M40 Grade of concrete. Gupta et al. and Jadon and Kumar [9, 10] found that the 40% replacement of river sand with stone dust enhanced the strength and durability characteristics of concrete. Patil Suraj et al. [11] shows that replacement of sand by stone dust in concrete reduces the cost of the concrete as well as saves large quantity of natural sand and thereby mitigates pollution created by the disposal of this stone dust on valuable fertile land. Moreover, the concrete with recycled concrete aggregates or waste ceramic

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 3, No. 3, March : 2024
aggregates as coarse aggregate showed good results of concrete strength and reduces the cost of material and construction cost and also minimizes the environment issues [2, 9].

Though several studies have been made on the use of stone dust, but a comprehensive investigation is still needed especially in case of nominal mixes. The use of river sand derived gravel, which is considered as a waste material, is yet to be investigated as a replacement for regular coarse aggregate in concrete. Using stone dustand river sand derived gravel in concrete can be useful to reduce pollution in the environment and makes better use of natural resources. The aim of this study is to provide valuable insights into thesuitability of stone dust and river sand derived gravel as a replacement material for sand and crushed stone (20mm) respectively and to understand its impact on concrete performance.

II. Materials

In this study, locally available river sand and crushed stone were used as the conventional fine aggregate and coarse aggregates in the concrete preparation respectively. Stone dust produced in a nearby quarry is collected and added in concrete as a replacement of sand in percentages of 0%, 20%, 40%, 60%, 80% and 100% by weight of dry sand. Crushed stone (20mm) and the river sand derived gravels (5mm) used in this study are designated as CA1 and CA2 respectively. The use of CA2 is fixed at 40% by total weight of coarse aggregates. In this experiment Portland Pozzolana Cement (PPC) were used. The images of river sand, stone dust, CA1 and CA2 used in this study are shown in Figures 1a, 1b, 1c and 1d. Table 1 and Table 2 depict the physical properties of cement and different fine and coarse aggregates respectively.



(a) (b)

(c) (d)

Figure 1: Images of (a) river sand, (b) stone dust, (c) CA1 and (d) CA2

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 3, No. 3, March : 2024

Table 1: Physical properties of cement

Sl. no	Characteristics	Test results	Value specified as
1	Fineness (As per IS: 4031-Part-1-1996)	6.04%	-
2	Normal Consistency (As per IS: 4031-Part-4-1988)	29 % of 300 gm of cement	-
3	Initial setting time (As per IS: 4031-Part-5-1988)	60 min	Not less than 30 minutes
4	Final setting time (As per IS: 4031-Part-5-1988)	360 min	Not less than 600 minutes
5	Specific gravity (As per IS: 4031-Part-11-1988)	3.07	

Table 2: Physical properties of fine and coarse aggregates

Sl. no	Characteristics	Fine aggregates		Coarse aggregates	
		Sand	Stone dust	20mm nominal size	Sand derived gravel
1	Specific gravity	2.62	2.66	2.67	2.68
2	Water absorption capacity (As per IS: 2386-Part-3-1963)	0.8	0.9%	1.0 %	0.8
3	Impact value (As per IS: 2386-Part-4-1963)	-	-	19.2%	-

Gradation of materials**:**

The sieve analysis of coarse aggregates was performed by using sieves of sizes 40 mm, 20 mm, 12.5 mm, 10 mm, and 4.75 mm. According to IS383-2016, the coarse aggregate of 20 mm size falls under the useable limit, whereas the river sand and stone dust fall in grading zone (i) and (iii) respectively. The gradation curves of different materials are shown in Figure 2.

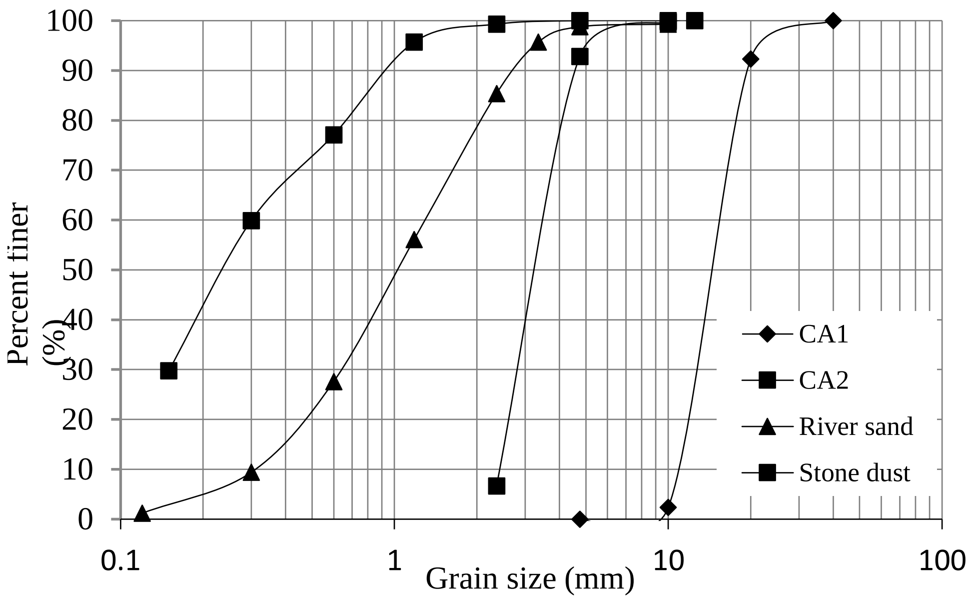


Figure 2: Gradation curves of coarse aggregates of 20 mm and 5 mm nominal size, river sand and stone dust

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 3, No. 3, March : 2024

Table 3: Sample of designations

Sl.no	Designations	Full form
1	C	Cement
2	S	Sand
3	SD	Stone dust
4	CA1	coarse aggregate (20mm nominal size)
5	CA2	Sand derived gravel (5mm)
6	C-SSD-CA1	Cement-sand/stone dust-sand derived gravel
7	C-SSD-(CA1) (CA2)	Cement-sand/stone dust-coarse aggregate/sand derived gravel
6	C+S+(CA1)	Cement + 100% sand+ 100% CA1
7	C+S+60(CA1)40(CA2)	Cement +sand+ (60% CA1+40%CA2)
8	C+80S20SD+60(CA1)40(CA2)	Cement + (80% sand + 20% stone dust) + (60% CA1+40%CA2)
9	C+80S20SD +CA1	Cement + (80% sand + 20% stone dust) + 100% CA1
10	C+SD +CA1	Cement + 100% stone dust + 100% CA1

III. Methodology

The proportion of concrete mix of ratio 1:1.5:3 (M20) was adopted for preparation of concrete cubes. Stone dust and river sand derived gravel were used as partial replacement of sand and crushed stone used as coarse aggregate in the concrete respectively. Use of stone dust in concrete can be a way out to conserve the natural river sand for future generations. Stone dust is a waste material obtained from stone quarry and coarse aggregate of 5mm nominal size (i.e., gravel) which is also considered as waste material in construction works. River sand is replaced by stone dust in percentages of 0%, 20%, 40%, 60%, 80%, 100% and coarse aggregate is used as a mixture of 60% crushed stone of 20mm nominal size and 40% sand derived gravels of 5 mm size. The cubes were made for different concrete mixes of M20 grade and then subjected to compression tests.

3.1 Casting and curing of cubes

At first, required quantities of various materials and water were determined for M20 grade of concrete by following the guideline given in IS 456: 2000, and were mixed thoroughly for casting. Cube moulds of (150 × 150×150) mm were used for casting. Initially, these cubes were kept at ambient condition for the first 24 hours as shown in Figure 3. After that, cubes were demoulded carefully so that no edges were broken and were placed in a curing tank for 7 days and 28 days (Figure 4). Care was taken to ensure the submersion of those cubes in the tank. The average result of compressive strength of concrete cubes for each concrete mix was reported as compressive strength of concrete for that particular mix.

Figure 3: Casting of cubes

Figure 4: Curing of cubes

IV. Results and Discussions

4.1 Workability

The consistency as well as workability of fresh concrete was measured by conducting slump test before it sets. Therefore, slump tests were performed to check the workability of freshly made concrete. Slump cone test was performed for various mixes and the slump values of those mixes are shown in Tables 4 and 5. The result shows that the workability of concrete mixes increased with an increase in percentage of stone dust as a partial replacement of fine aggregate (Table 4).

Workability of concrete depends on size, shape and grading of aggregates. If size increases then workability also increases. If shape of aggregates is round, it provides better workability than angular, elongated, or flaky aggregate, therefore, gravel or coarse aggregates obtained from river provide greater workability to concrete than crushed aggregates. Additionally, grading influences more on workability. The better the grading the higher will be the workability. A well graded aggregate shows higher degree of workability. Table 5 depicts that C+S+60(CA1)40(CA2) mix shows higher slump value of 148 mm than C+S+(CA1) mix which show a slump value of 131 mm and it is due the fact that C+S+60(CA1)40(CA2) mix contains CA2 which is of round shaped compared to CA1.

Table 4: Summary of Slump tests result of C-SSD-CA1 concrete mixes

Sl. No.	Mixes	Slump value(mm)
1.	C+S+(CA1)	152
2.	C+80S20SD+(CA1)	150
3.	C+60S40SD+(CA1)	147
4.	C+40S60SD+(CA1)	143
5.	C+20S80SD+(CA1)	140
6.	C+SD+(CA1)	135

Table 5: Summary of Slump tests result of C-SSD-(CA1) (CA2) concrete mixes

Sl. No.	Mixes	Slump value(mm)
1.	C+S+(CA1)	152
2.	C+S+60(CA1)40(CA2)	159
3.	C+80S20SD+60(CA1)40(CA2)	157
4.	C+60S40SD+60(CA1)40(CA2)	152
5.	C+40S60SD+60(CA1)40(CA2)	149
6.	C+20S80SD+60(CA1)40(CA2)	142
7.	C+SD+60(CA1)40(CA2)	137
8.	C+SD+(CA1)	135

4.2 Compressive strength results

Figures 5 and 6 show the changes in compressive strength of cubes for M20 grade of concrete containing cement, sand, stone dust, and crushed stones in different proportions along with varying curing periods (7 days and 28 days). The compressive strength value of each mix represents the average of three test results and these are shown in Tables 6 and 7. The result indicates that the concrete containing 20% stone dust as a replacement for sand, exhibits higher strength compared to the control concrete.

The change in compressive strength of C-(SSD) -(CA1) (CA2) concrete mixes for 7 days and 28 days curing periods are shown in Figures 7 and 8. The compressive strength values of different concrete mixes are shown in Tables 8 and 9. The result indicate that the concrete containing 20% stone dust as a replacement for sand along with a mixture of 60% CA1 and 40% CA2 exhibits higher strength compared to the control concrete i.e., C+S+(CA1).

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 3, No. 3, March : 2024

From the compressive tests results of different concrete mixes it is found that C-SSD-(CA1) mixes containing 20mm nominal size coarse aggregate shows greater compressive strength then C-SSD-(CA1) (CA2) concrete mixes containing the mixer of 60% CA1 and 40% CA2 coarse aggregate. This kind of finding is seen for both curing periods i.e., for 7 days and 28 days curing period. It is found that lean mix of weaker concrete having larger aggregate gives high strength, while in high strength concrete it is the smaller aggregate which yields high strength (<25Mpa).

The value of Compressive strength of concrete were observed to be maximum at 30% of stone dust [1]. Babu et al. [4] reported that the strength increased at 25% of stone dust. Jadon and Kumar [10] found that replacement of recycled concrete aggregate with conventional coarse aggregate and 40%replacement of river sand with stone dust enhanced the concrete strength (M20 &M30) design mix. Gupta [9] also reported that compressive strength was increased at 30% stone dust. Maximum strength was obtained at 40% stone dust and 20% waste ceramic aggregates and at 0% stone dust use of ceramic waste as coarse aggregate reduces the strength of concrete [5]. Khode et al. [6] obtained maximum strength at 50% stone dust content.

Table 6: Summary of compressive tests results of C-SSD-CA1 concrete mixes for 7 days curing period

Sl. no	Mixes	Average compressive strength, N/mm^2 for 7 days
1	C+S+(CA1)	10.32
2	C+80S20SD+(CA1)	13.33
3	C+60S40SD+(CA1)	11.48
4	C+40S60SD+(CA1)	9.03
5	C+20S80SD+(CA1)	7.81
6	C+SD+(CA1)	6.85

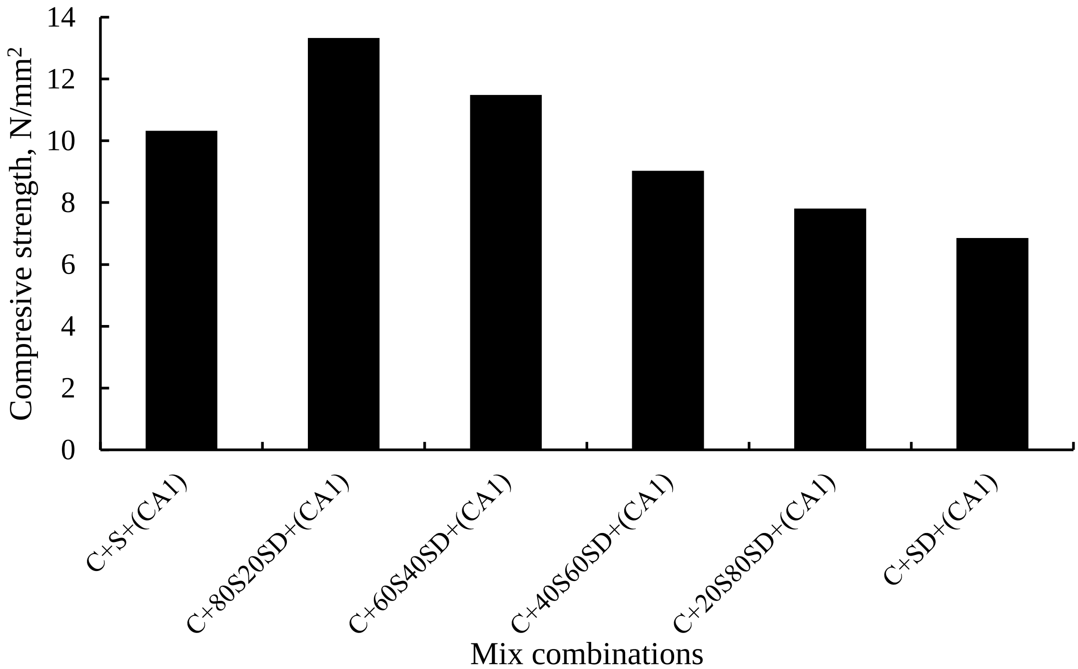


Figure 5: Bar chart of Compressive strength of M20 Grade of Concrete containing different C-SSD-CA1 mixes for 7 days curing

Table 7: Summary of compressive tests results of C-(SSD) - (CA1) concrete mixes for 28 days curing period

Sl. no	Mixes	Average compressive strength, N/mm^2 for 28 days
1	C+S+ (CA1)	19.25
2	C+80S20SD+(CA1)	22.59
3	C+60S40SD+(CA1)	18.1
4	C+40S60SD+(CA1)	17.69
5	C+20S80SD+(CA1)	15.55
6	C+SD+(CA1)	13.1

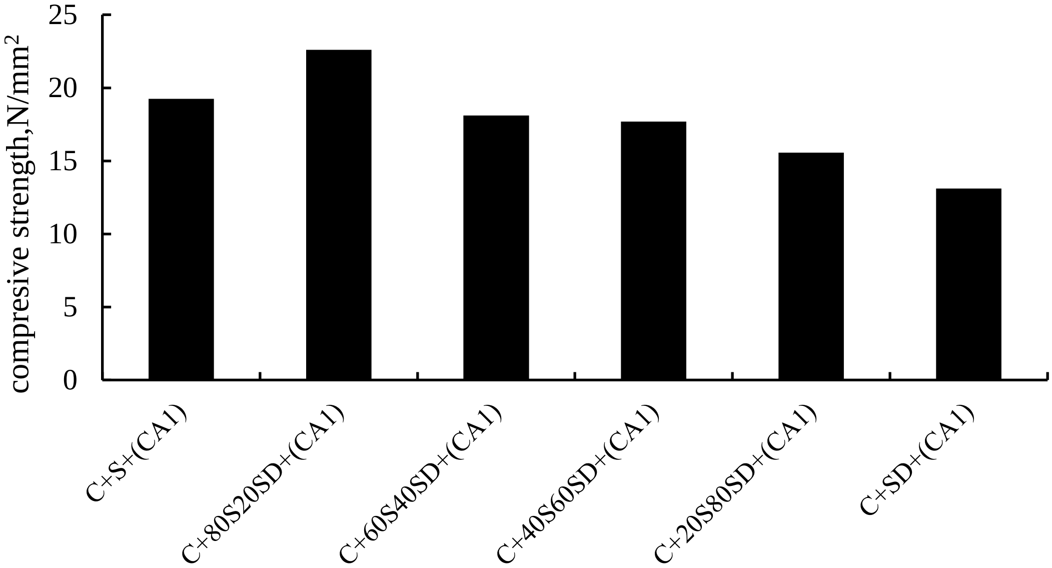


Figure 6: Bar chart of Compressive strength of M20 Grade of Concrete containing different C-SSD-CA1 mixes for 28 days curing

Table 8: Summary of compressive tests results of C-SSD-(CA1) (CA2) concrete mixes for 7 days curing period

Sl. No.	Mixes	Average compressive strength, N/mm2 for 7 days
1	C+S+(CA1)	10.32
2	C+S+60(CA1)40(CA2)	9.4
3	C+80S20SD+60(CA1)40(CA2)	11.09
4	C+60S40SD+60(CA1)40(CA2)	9.62
5	C+40S60SD+60(CA1)40(CA2)	8.07
6	C+20S80SD+60(CA1)40(CA2)	7.03
7	C+SD+60(CA1)40(CA2)	6.29
8	C+SD+(CA1)	6.85

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 3, No. 3, March : 2024

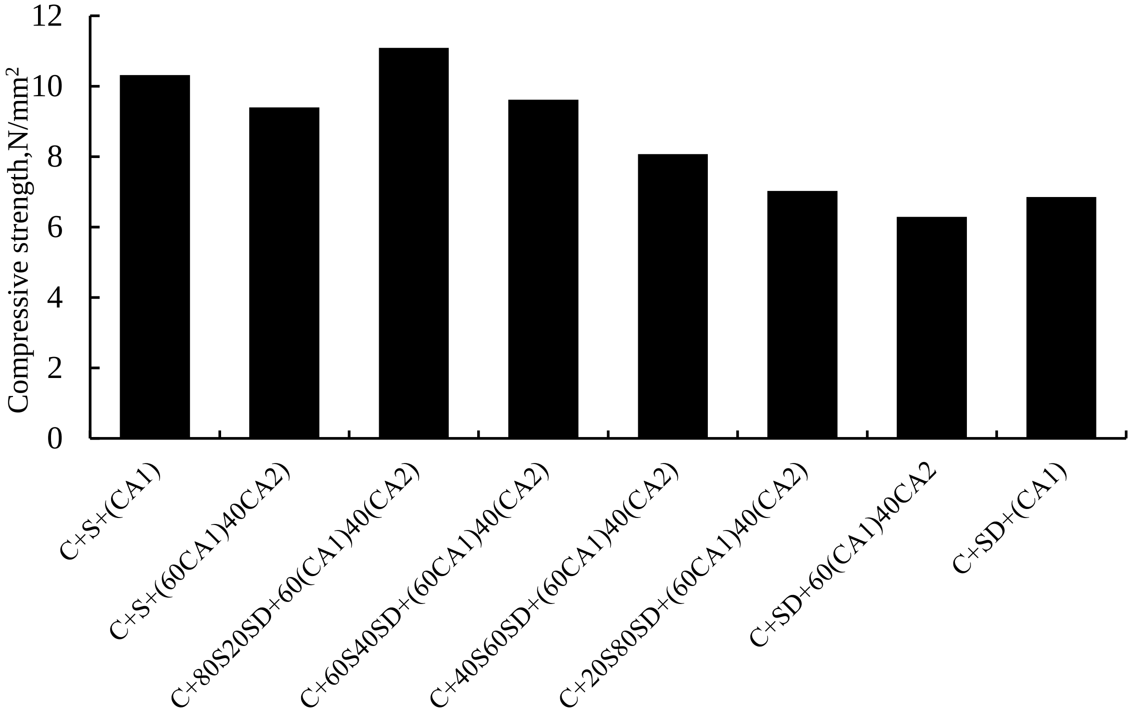


Figure 7: Bar chart of compressive strength of different C-SSD-(CA1) (CA2) concrete mixes for 7 days curing

Table 9: Summary of compressive tests results of C-(SSD) - (CA1) (CA2) concrete mixes for 28 days curing period

Sl no	Mixes	Average compressive strength, N/mm^2 for 28 days
1	C+S+(CA1)	19.25
2	C+S+60(CA1)40(CA2)	17.33
3	C+80S20SD+(CA1)40(CA2)	21.72
4	C+60S40SD+(CA1)40(CA2)	17.59
5	C+40S60SD+(CA1)40(CA2)	15.7
6	C+20S80SD+(CA1)40(CA2)	13.23
7	C+SD+(CA1)40(CA2)	11.03
8	C+SD+(CA1)	13.1

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 3, No. 3, March : 2024

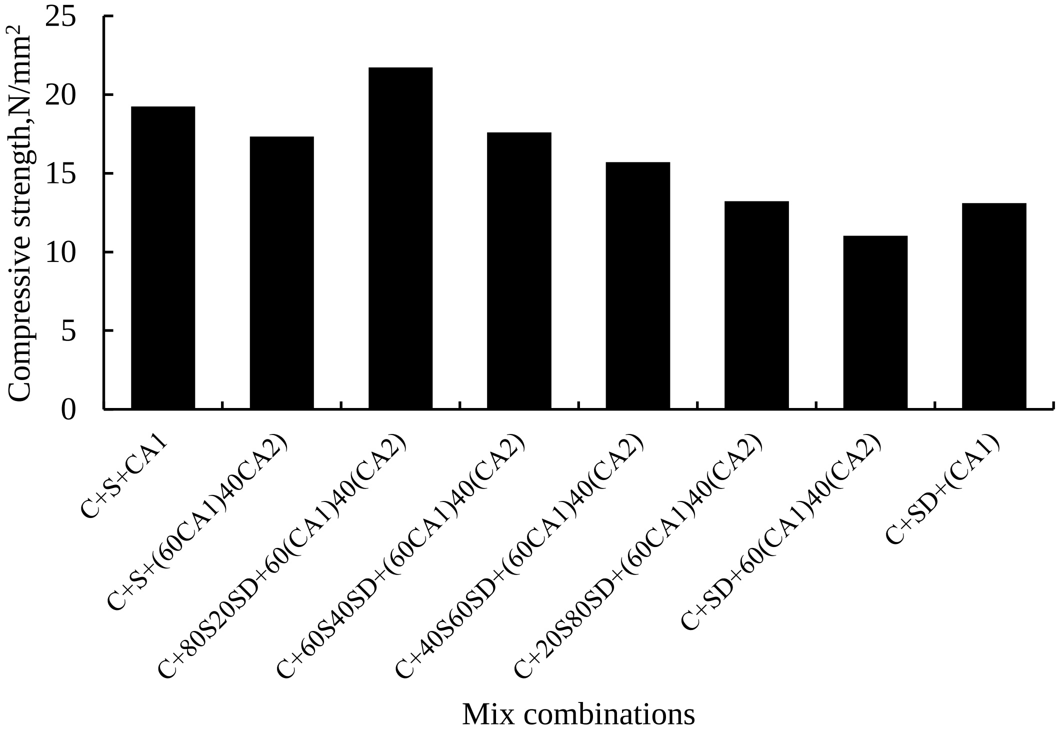


Figure 8: Bar chart of compressive strength of different C-SSD-(CA1) (CA2) concrete mixes with 28 days curing

V. CONCLUSIONS

Based on the present study following conclusions have been drawn:

1. Generally, inclusion of stone dust and sand derived gravels as replacement of river sand and crushed stone in concrete reduces the slump values of concrete mixes. But still the workability is found to be within permissible limit.
2. The result indicates that replacing 20% of river sand and 40% of coarse aggregates (20 mm) with stone dust and sand derived gravel respectively in concrete improves the compressive strength of concrete. After 28 days the compressive strength of C+80S20SD+60$CA_1$40CA_2 concrete mix is found to be 22.5 N/mm^2 which is higher than the control mix.
3. The findings of this study suggest that 20% quarry dust and 40% of sand derived gravels (5mm) can be used as partial replacement materials for fine aggregate and coarse aggregate in concrete.

Acknowledgement

The authors are grateful to the students and laboratory staffs of Department of Civil Engineering of Central Institute of Technology Kokrajhar for their support in carrying out this study and successful completion of the work.

References

[1] Nuruzzaman M. Islam M S, Salauddin M, "Strength Aspect of Concrete Using Stone Dust as A Partial Replacement of Sand", International Journal of Advanced Structures and Geotechnical Engineering, Vol. 4, no-4, pp 237- 242, 2015.

[2] Rajput S P S, "An experimental study on crushed stone dust as fine aggregates in cement concrete", Materials today: Proceedings, Vol. 5, no-9, pp 17540-17547, 2018.

[3] Suman B K, "Suitability of Stone Dust in Concrete", International Journal of Engineering Development and Research, Vol. 6, no-2, pp 629-633, 2018.

[4] Babu Y A, Musalaiah M & Srikanth B, "Investigations on Various Concrete Properties by

Replacement of Fine Aggregate with Stone (Quarry) Dust," International Journal of Scientific Research and Engineering Trends, Vol. 7, no-4, pp 2439-2443, 2021.
[5] Gupta A, Gupta N, Saxena K K & Goial S K, "Investigation of The Mechanical Strength of Stone Dust and Ceramic Waste Based Composite", Material Today: Proceedings, Vol. 44, no-1, pp 29-23, 2021.
[6] Khode B V, Wadhai P J & Ghodmare S D & Khan H A, "Feasibility Study on Impact of Replacement of River Sand with Crushed Aggregate in Concrete Mix", Materials today: Proceedings, https://doi.org/10.1016/j.matpr.2023.08.273, 2023.
[7] Venktesh D, Uwais M & Samhitha K V, "Replacement of Quarry Waste as Fine Aggregate in the Preparation of Self-Compacting Concrete", Industrial Engineering Journal, Vol. 52, No. 3, pp 699-708, 2023.
[8] Khan M S & Kumar B, 'Concrete Mix Design Philosophy to Achieve the Required Strength by Using Waste Crushed Stone Sand", Industrial Engineering Journal, Vol. 52, pp 221-227, 2023.
[9] Gupta T, Kothari S, Siddique S, Sharma R. K. & Choudhary S, "Influence of Stone Processing Dust on Mechanical, Durability and Sustainability of Concrete", Construction and Building Materials, Vol. 223, pp 918-927, 2019.
[10] Jadon S & Kumar S, "Stone Dust and Recycled Concrete Aggregate in Concrete Construction: An Efficient Way of Sustainable Development," Materials Today: Precedings, https://doi.org/10.1016/j.matpr.2023.04.221, 2023.
[11] Patil S N, Talekar A S, Tembare N V & Memane A A, "The Utilizationof Crushed Stone Dust as A Replacement of Sand in Cement Concrete", Journal of Information, Knowledge and Research in Civil Engineering Vol.4, no-2, pp. 478-481, 2016.
[12] IS 456 (2000): Plain and reinforcement concrete-Code of practice, Bureau of Indian Standards, Manak Bhavan, Bahadur Shah Zafar Marg, New Delhi 110002.
[13] IS 383-2016: Coarse and fine aggregate for concrete- Specification, Bureau of Indian Standards, Manak Bhavan, Bahadur Shah Zafar Marg, New Delhi 110002.