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An Experimental Investigation on Concrete by Partial Replacement of Fine Aggregate with Stone Dust and Waste Foundry Sand

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Abstract: This research study includes check the feasibility and performance of stone dust and waste foundry sand in concrete. In this study experimental investigation are performed to evaluate the fresh and hardened properties of concrete containing stone dust and waste foundry sand as fine aggregate replacement. Fine aggregate are replaced partially with stone dust and waste foundry sand.

The percentages of replacement 0%, 20%, 30%, 40%, 50% by weight of fine aggregate with stone dust and 0%, 10%, 15%, 20%, 25% by weight of fine aggregate with waste foundry sand. The fresh properties like slump test, compacting factor test and hardened properties like compression strength test at 7 and 28 days of curing, split tensile strength test, flexural strength test at 28 days of curing performed for all replacement levels for M30 grade concrete.

The test results indicates the stone dust and waste foundry sand can be used effectively to replace fine aggregate in concrete. In the experimental investigation of strength characteristics of concrete using stone dust and waste foundry sand as fine aggregate it is found that there is increase in compressive strength, split tensile strength and flexural strength.

Keywords: Fine Aggregate (FA), Stone Dust (SD), Waste Foundry Sand (WFS), Workability, Compressive Strength, Split Tensile Strength, Flexural Strength.

I. INTRODUCTION

Concrete is the most vital material in modern day construction. It is known for versatile properties like high compressive strength and long lasting durability.

Due to rapid growth in construction activity, the consumption of concrete is increasing every year. This results in excessive exploitation of natural resources.

In some places either natural sand may not be of good quality or good quality sand has to be transported from long distances, which adds to the cost of construction.

Therefore, it is becoming inevitable to replace natural sand in concrete by an alternative material either partially or completely without affecting the quality of concrete.

Large scale efforts are required for reducing the usage of the raw materials that are currently available, so that large replacement is using the various by-product materials that are easily accessible in present day.

Stone dust or quarry dust can be defined as residue, tailing or other non-voluble waste material after the extraction and processing of rocks to form fine particles less than 4.75 mm.

It has very recently gained good attention to be used as an effective filler material instead of fine aggregate. Stone dust is an industrial by-product. It is formed by screening products of secondary and subsequent stages of crushing igneous rocks, sedimentary rocks or gravel.

It can be classified by the size of the particles as 0 to 4.75 mm. Waste foundry sand is high quality silica sand that is a byproduct from the production of both ferrous and nonferrous metal castings. A foundry is a manufacturing facility that produces metal castings by pouring molten metal into a preformed mold to yield the resulting hardened cast. The characteristics of foundry sand will depend in great part on the type of casting process and the industry sector from which it originates. The innovative and new research must be required for utilization of foundry sand waste materials. These research efforts try to match society’s need for safe and economic utilization of foundry sand waste materials.

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II. MATERIAL

A. Cement
Cement is the binding material in the cement concrete. The Ordinary Portland Cement of 53 grade confirming to IS: 12269-2013 was used for this experimental work.

B. Coarse Aggregate
Locally available 20 mm and 10 mm coarse aggregate is used for this experimental study. The coarse aggregate from crushed basalt rock confirming to IS: 383-2016 is used. It is mixed in proportion of 60:40 percent.

C. Fine Aggregate
The naturally available river sand used as fine aggregate. The fine aggregate Zone II passed through 4.75 mm and retained on 150 µ sieve is used confirming to the requirements of IS: 383-2016.

D. Stone Dust
Stone dust is collected from local stone crusher plant. Particle size passed through 4.75 mm and retained on 150 µ sieve and specific gravity 2.52 consists of used.

E. Waste Foundry Sand
Waste foundry sand is collected from Raj Technocast Pvt. Ltd.-Rajkot Particle size passed through 4.75 mm and retained on 150 µ sieve and specific gravity 2.59 consists of used.

F. Waster
The potable water used in the present study.
Physical properties of experimental materials are as shown in Table 1.

TABLE 1 PHYSICAL PROPERTIES OF EXPERIMENTAL MATERIALS

Sr. No.	Test	Coarse Aggregate	Fine Aggregate	Stone Dust	Waste Foundry Sand	IS Code
1	Specific Gravity	2.84	2.71	2.52	2.59	IS: 2386-1963 (Part III)
2	Water Absorption	0.51 %	0.76 %	0.94 %	0.78%	
3	Free Surface Moisture	Nil	0.60 %	Nil	Nil	
4	Fineness Modulus	-	2.92	2.60	2.01	IS: 383-2016
5	Sieve Analysis	-	Zone - II	Zone - II	Zone - III	

III.EXPERIMENTAL METHODOLOGY

A. Concrete Mix Design Proportions
In this experimental study trial mixes for different proportion of ingredients are designed for M30 grade of concrete as per IS: 10262-2009, the concrete mix design proportions are as shown in Table 2. The target mean strength was 38.25 N/mm² for the control mix, the W/C ratio kept 0.45.

TABLE 2 CONCRETE MIX DESIGN PROPORTIONS FOR M30 GRADE

Volume of Concrete	Cement	Fine Aggregate	Coarse Aggregate (20 mm)	Coarse Aggregate (10 mm)	Water
By Weight	425.73 kg/m³	675.08 kg/m³	722.77 kg/m³	481.84 kg/m³	198.72 litre
By Volume	1.00	1.59	2.83		0.45

B. Mixing and Casting Details of Specimen
In this experimental study fine aggregate replaced with stone dust, waste foundry sand, combination of stone dust and waste foundry sand with different proportions, the details of mixing and specimen designations are as shown in Table 3. All the specimens used in the experimental work were recommended by IS: 516-1959, cubical moulds of size 150 x 150 x 150 mm were used for the finding compressive strength. Cylindrical moulds of 150 mm diameter and 300 mm length, concrete specimens were prepared for the determinations of split tensile strength. Beams having size of 100 x 100 x 500 mm were prepared to evaluate the flexural strength.

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TABLE 3
DETAILS OF MIXING AND SPECIMEN DESIGNATION

Identification Mark	FA %	SD %	WFS %	Description
M1	100	0	0	Control Mix
M2	80	20	0	20% replacement of the FA by SD
M3	70	30	0	30% replacement of the FA by SD
M4	60	40	0	40% replacement of the FA by SD
M5	50	50	0	50% replacement of the FA by SD
M6	90	0	10	10% replacement of the FA by WFS
M7	85	0	15	15% replacement of the FA by WFS
M8	80	0	20	20% replacement of the FA by WFS
M9	75	0	25	25% replacement of the FA by WFS
M10	60	30	10	30% replacement of the FA by SD and 10% by WFS
M11	55	30	15	30% replacement of the FA by SD and 15% by WFS
M12	50	30	20	30% replacement of the FA by SD and 20% by WFS
M13	50	40	10	40% replacement of the FA by SD and 10% by WFS
M14	45	40	15	40% replacement of the FA by SD and 15% by WFS
M15	40	40	20	40% replacement of the FA by SD and 20% by WFS
M16	40	50	10	50% replacement of the FA by SD and 10% by WFS
M17	35	50	15	50% replacement of the FA by SD and 15% by WFS
M18	30	50	20	50% replacement of the FA by SD and 20% by WFS

* FA = Fine Aggregate, SD = Stone Dust, WFS = Waste Foundry Sand.

IV. RESULTS AND DISCUSSION

A. Fresh Concrete Properties

Fresh properties of M30 grade of concrete are as shown in Table 4.

TABLE 4 FRESH CONCRETE PROPERTIES

Concrete Mix	FA %	SD %	WFS %	Slump (mm)	Compacting Factor
M1	100	0	0	63	0.89
M2	80	20	0	56	0.83
M3	70	30	0	52	0.78
M4	60	40	0	46	0.74
M5	50	50	0	41	0.71
M6	90	0	10	58	0.87
M7	85	0	15	54	0.84
M8	80	0	20	49	0.79
M9	75	0	25	44	0.72
M10	60	30	10	54	0.83
M11	55	30	15	51	0.79
M12	50	30	20	45	0.75
M13	50	40	10	51	0.76
M14	45	40	15	47	0.74
M15	40	40	20	42	0.70
M16	40	50	10	48	0.73
M17	35	50	15	44	0.71
M18	30	50	20	41	0.68

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1) *Slump Test*: From the observation replacement of SD with FA in concrete the slump was decreases. The percentages of replacement of SD was increases from 20% to 50%, the slump was decreases from 11.11% to 34.92% as compare to normal concrete test results. From the observation replacement of WFS with FA in concrete the slump was decreases. The percentages of replacement of WFS was increases from 10% to 25%, the slump was decreases from 7.94% to 30.16% as compare to normal concrete test results. From the observation replacement of both SD and WFS with FA in concrete the slump was decreases. The percentages of replacement of SD was increases from 30% to 50% and WFS was increases from 10% to 20%, the slump was decreases from 14.29% to 34.92% as compare to normal concrete test results.

Slump test results of concrete mix are as shown in Figure 1.

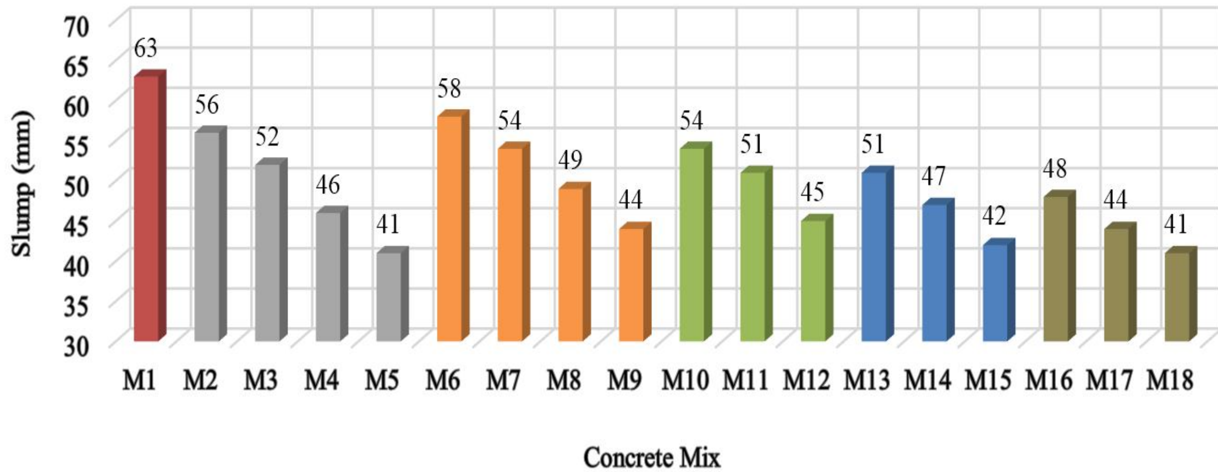

Fig. 1 Slump Test Results of Concrete Mix

2) *Compacting Factor Test:* From the observation replacement of SD with FA in concrete the compacting factor was decreases. The percentages of replacement of SD was increases from 20% to 50%, the compacting factor was decreases from 6.74% to 20.22% as compare to normal concrete test results. From the observation replacement of WFS with FA in concrete the compacting factor was decreases. The percentages of replacement of WFS was increases from 10% to 25%, the compacting factor was decreases from 2.25% to 19.10% as compare to normal concrete test results. From the observation replacement of both SD and WFS with FA in concrete the compacting factor was decreases. The percentages of replacement of SD was increases from 30% to 50% and WFS was increases from 10% to 20%, the compacting factor was decreases from 6.74% to 23.60% as compare to normal concrete test results.

Compacting factor test results of concrete mix are as shown in Figure 2.

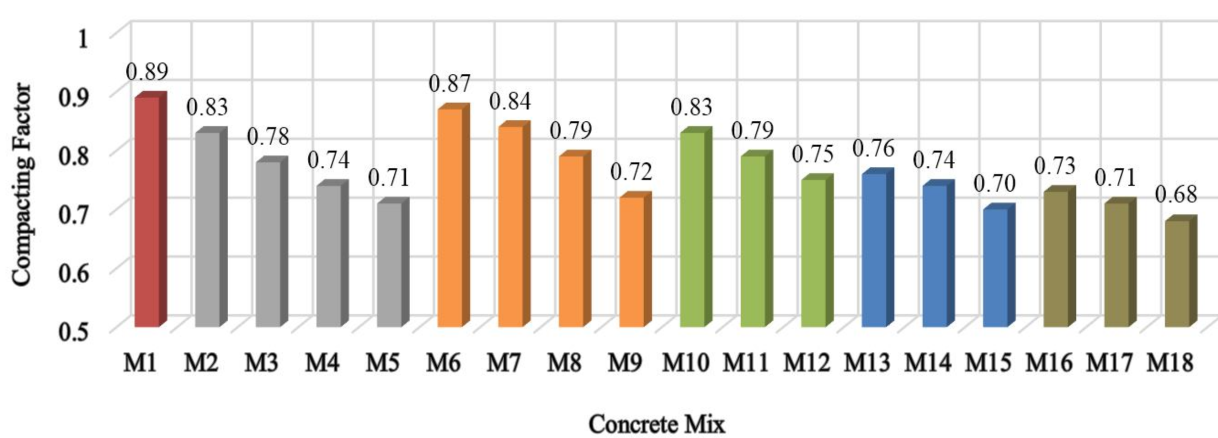

Fig. 2 Compacting Factor Test Results of Concrete Mix

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B. Hardened Concrete Properties

Hardened properties of M30 grade of concrete are as shown in Table 5.

TABLE 5
HARDENED CONCRETE PROPERTIES

Concrete Mix	FA %	SD %	WFS %	Compressive Strength (N/mm²)		Split Tensile Strength (N/mm²)	Flexural Strength (N/mm²)
				7 Days	28 Days	28 Days	28 Days
M1	100	0	0	26.92	40.22	3.05	4.08
M2	80	20	0	27.76	41.94	3.19	4.27
M3	70	30	0	28.64	42.84	3.32	4.47
M4	60	40	0	29.97	43.79	3.44	4.65
M5	50	50	0	27.45	40.79	3.12	4.39
M6	90	0	10	28.55	42.49	3.17	4.20
M7	85	0	15	29.56	43.60	3.30	4.48
M8	80	0	20	28.44	41.88	3.21	4.29
M9	75	0	25	27.34	40.74	3.08	4.15
M10	60	30	10	27.49	41.36	3.14	4.25
M11	55	30	15	28.31	42.27	3.26	4.44
M12	50	30	20	27.45	40.77	3.13	4.24
M13	50	40	10	28.27	42.19	3.27	4.48
M14	45	40	15	28.80	42.99	3.38	4.61
M15	40	40	20	27.23	40.64	3.18	4.33
M16	40	50	10	27.61	41.17	3.15	4.24
M17	35	50	15	28.27	42.16	3.24	4.41
M18	30	50	20	27.19	40.58	3.13	4.21

1) *Compressive Strength Test*: From the observation replacement of SD with FA in concrete the compressive strength was increases up to 40%. The percentages of replacement of SD was increases from 20% to 50%, the maximum compressive strength was observed at 40% as 8.88% as compared to normal concrete test results at 28 days. From the observation replacement of WFS with FA in concrete the compressive strength was increases up to 15%. The percentages of replacement of SD was increases from 10% to 25%, the maximum compressive strength was observed at 15% as 8.40% as compared to normal concrete test results at 28 days. From the observation replacement of SD and WFS with FA in concrete the compressive strength was increases up to 40% + 15%. The percentages of replacement of SD was increases from 30% to 50% and WFS was increases from 10% to 20%, the maximum compressive strength was observed at 40% + 15% as 6.89% as compared to normal concrete test results at 28 days.

Compressive strength test results of concrete mix are as shown in Figure 3.

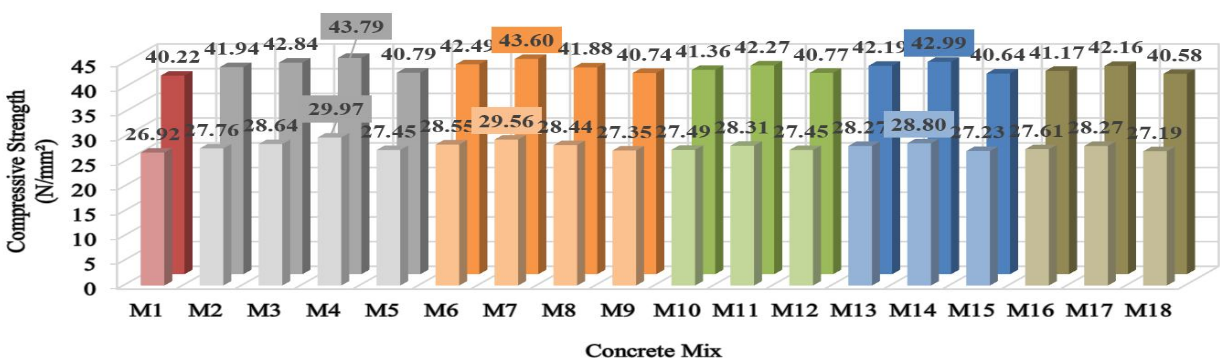

Fig. 3 Compressive Strength Test Results of Concrete Mix at 7 and 28 Days

2) *Split Tensile Strength Test:* From the observation replacement of SD with FA in concrete the split tensile strength was increases up to 40%. The percentages of replacement of SD was increases from 20% to 50%, the maximum split tensile strength was observed at 40% as 12.85% as compared to normal concrete test results at 28 days. From the observation replacement of WFS with FA in concrete the split tensile strength was increases up to 15%. The percentages of replacement of SD was increases from 10% to 25%, the maximum split tensile strength was observed at 15% as 8.36% as compared to normal concrete test results at 28 days. From the observation replacement of SD and WFS with FA in concrete the split tensile strength was increases up to 40% + 15%. The percentages of replacement of SD was increases from 30% to 50% and WFS was increases from 10% to 20%, the maximum split tensile strength was observed at 40% + 15% as 10.84% as compared to normal concrete test results at 28 days.

Split tensile strength test results of concrete mix are as shown in Figure 4.

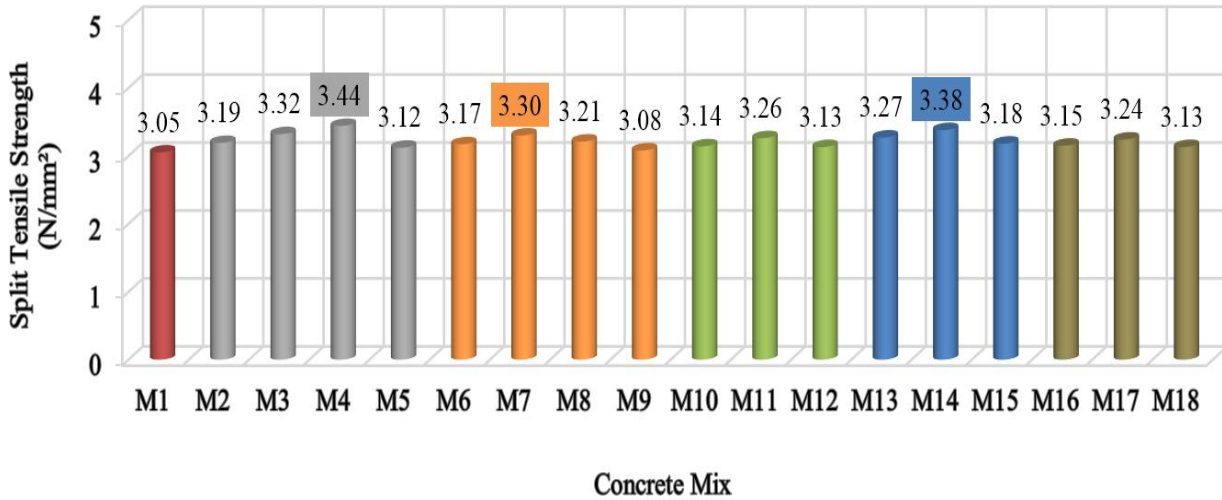

Fig. 4 Split Tensile Strength Test Results of Concrete Mix at 28 Days

3) *Flexural Strength Test:* From the observation replacement of SD with FA in concrete the flexural strength was increases up to 40%. The percentages of replacement of SD was increases from 20% to 50%, the maximum flexural strength was observed at 40% as 14.05% as compared to normal concrete test results at 28 days. From the observation replacement of WFS with FA in concrete the flexural strength was increases up to 15%. The percentages of replacement of SD was increases from 10% to 25%, the maximum flexural strength was observed at 15% as 9.80% as compared to normal concrete test results at 28 days. From the observation replacement of SD and WFS with FA in concrete the flexural strength was increases up to 40% + 15%. The percentages of replacement of SD was increases from 30% to 50% and WFS was increases from 10% to 20%, the maximum flexural strength was observed at 40% + 15% as 13.07% as compared to normal concrete test results at 28 days.

Flexural strength test results of concrete mix are as shown in Figure 5.

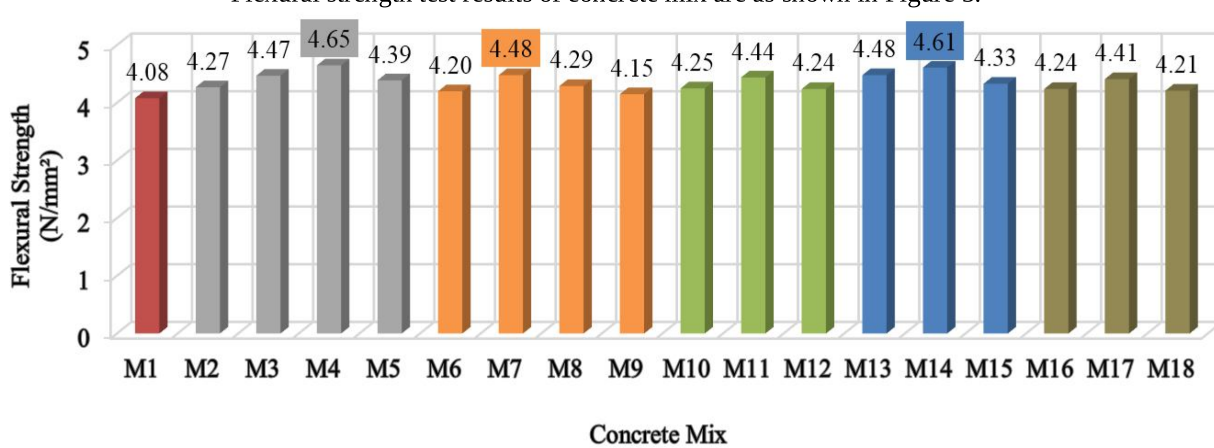

Fig. 5 Flexural Strength Test Results of Concrete Mix at 28 Days

V. CONCLUSIONS

Following broad conclusions are drawn from this experimental investigation.

A. The percentage of replacement of stone dust and waste foundry sand was increases, workability of fresh concrete was decreases.
B. Partial replacement of fine aggregate with SD (up to 40%) and WFS (up to 15%) increases strength properties such as compressive, split tensile and flexural strength of M30 grade of concrete.
C. By replacement 40% fine aggregate with stone dust the compressive strength was increases by 8.88% at 28 days as compared to normal concrete. By replacement 15% fine aggregate with waste foundry sand the compressive strength was increases by 8.40% at 28 days as compared to normal concrete. By replacement 40% fine aggregate with stone dust and 15 % fine aggregate by waste foundry sand the compressive strength was increases by 6.89% at 28 days as compared to normal concrete.
D. By replacement 40% fine aggregate with stone dust the split tensile strength was increases by 12.85% at 28 days as compared to normal concrete. By replacement 15% fine aggregate with waste foundry sand the split tensile strength was increases by 8.36% at 28 days as compared to normal concrete. By replacement 40% fine aggregate with stone dust and 15 % fine aggregate by waste foundry sand the split tensile strength was increases by 10.84% at 28 days as compared to normal concrete.
E. By replacement 40% fine aggregate with stone dust the flexural strength was increases by 14.05% at 28 days as compared to normal concrete. By replacement 15% fine aggregate with waste foundry sand the flexural strength was increases by 9.80% at 28 days as compared to normal concrete. By replacement 40% fine aggregate with stone dust and 15 % fine aggregate by waste foundry sand the flexural strength was increases by 13.07% at 28 days as compared to normal concrete.
F. Fine aggregate can be effectively replaced by SD (up to 40%) and WFS (up to 15%) increase strength properties of M30 grade of concrete.

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REFERENCES

[1] Sanjay Mundra, P. R. Sindhi, Vinay Chandwani, Ravindra Nagar and Vinay Agrawal, “Crushed Rock Sand – An Economical and Ecological Alternative to Natural Sand to Optimize Concrete Mix”, Elsevier, Perspective in Science, 8, pp. 345-347, April 2016.
[2] Er. Lalit Kumar and Er. Arvinder Singh, “A Study on the Strength of Concrete Using Crushed Stone Dust as Fine Aggregate”, International Journal for Research in Applied Science and Engineering Technology (IJRASET), vol. 3, pp. 308-316, January 2015.
[3] Franklin Eric Kujur, Vikas Srivastava, V. C. Agrawal, Anjelo F. Denis and Ehsan Ali, “Stone Dust as Partial Replacement of Fine Aggregate in Concrete”, Journal of Academia and Industrial Research (JAIR), vol. 3, pp. 148-151, August 2014.
[4] Thiruvenkitam Manoharan, Dhamothiran Laksmanan, Kaliyannan Mylsamy, Pandian Sivakumar and Anirbid Sircar, “Engineering Properties of Concrete with Partial Utilization of Used Foundry Sand”, Elsevier, Waste Management, 71, pp. 454-460, November 2017.
[5] Pranita Bhandari and Dr. K. M. Tajne, “Use of Foundry Sand in Conventional Concrete”, International Journal of Latest Trends in Engineering and Technology (IJLTET), vol. 6, pp. 249-254, January 2016.
[6] Rafat Siddique, Gurpreet Singh, Rafik Belarbi, Karim Ait-Mokhtar and Kunal, “Comparative Investigation on the Influence of Spent Foundry Sand as Partial Replacement of Fine Aggregate on the Properties of Two Grades of Concrete ”, Elsevier, Construction and Building Materials, 83, pp. 216-222, March 2015.
[7] IS: 383-2016, Indian Standard Code of Coarse and Fine Aggregate for Concrete – Specification, Bureau of Indian Standards, New Delhi, India.
[8] IS: 2386 (Part III)-1963, Indian Standard Code of Practice – Methods of Test for Aggregate for Concrete, Bureau of Indian Standards, New Delhi, India.
[9] IS: 10262-2009, Recommended Guidelines for Concrete Mix Designs, Bureau of Indian Standards, New Delhi, India.
[10] IS: 12269-2013, Indian Standard Specification for 53 Grade Ordinary Portland Cement, Bureau of Indian Standards, New Delhi, India.
[11] IS: 456-2000, Plain and Reinforced concrete – Code of Practice, 4th revision, Bureau of Indian Standards, New Delhi, India.
[12] IS: 1199-1959, Indian Standard Code of Method of Sampling and Analysis of Concrete, Bureau of Indian Standards, New Delhi, India.
[13] IS: 516-1959, Indian Standard Code of Method of Test for Strength of Concrete, Bureau of Indian Standards, New Delhi, India.
[14] IS: 5816-1999, Indian Standard Code of Method of Test for Splitting Tensile Strength of Concrete, Bureau of Indian Standards, New Delhi, India.
[15] M. S. Shetty, Concrete Technology Theory and Practice, 6th edition, S. Chand and Company Ltd., New Delhi, India, May 2005.