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Comparative Study on Kota Stone Slurry as Partial Replacement of Cement with Conventional and M-Sand Mixed Concrete

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Abstract: ***Concrete is the most often utilized manufactured material in buildings. The need for concrete is rapidly increasing as the infrastructure industry grows, raising environmental concerns. Concrete is made of cement as a binder and river sand as fine aggregate. In this study feasibility of the Kota stone slurry is examined with both natural and manufactured sand. Replacement levels for Kota stone slurry were kept from 0 to 25% at an increment of 5%. The requirement of SP dosage was considered for each mix at an acceptable compaction factor. Mechanical strength like compression, flexural and tensile for each mix is compared. For the durability aspect, the volume of voids and permeability is inspected and compared. Overall, it can be concluded from above observation that optimum 15% for Kota stone slurry in both type sand mixes can be utilized in concrete sample.***

Keywords: M-Sand, Kota Stone Slurry, Mechanical strength, Permeability etc.

1. Introduction

India has large reserves of dimensional stones such as limestone, marble, dolomite, and Kota stone, etc. India is the 3rd largest exporter in the stone industry and it has more than 25% of stone reserves of the world out of which most of the stone reserves are found in Rajasthan state. Rajasthan is situated in the northwestern part of India and in area wise it is the largest state of India having approximately 11% of the country’s total geographical area.

Scope of Study

Various stones such as marble, granite, sandstone, Kota stone, and many other dimensional stones are found in abundance in the upper Vindhya region of Rajasthan. These stones are generally used as a building material for decorative purposes. During the processing and finishing process of these stones, a huge quantity of fine particle waste is produced.

2. Literature Review

A literature study is essential for improving knowledge about the examination region and identifying that the major challenge facing with that space has been resolved and should be addressed in the future. An acceptable writing survey creates a framework for an acceptable research study.

Weiguo Shen et al, 2018, studied the impact of manufactured sand on the performance of concrete. An experimental study was done by preparing concrete with crushed limestone as coarse aggregate and manufactured sand as fine aggregate. Some percentage of stone powder waste (less than 75 microns) was replaced with manufactured sand in fine aggregate to examine its influence on 12 manufactured sand.

Aman Jain and Rohan Majumdar, 2016, carried out research on the use of Kota stone slurry in concrete by partially replacing it with cement. Locally available Kota stone slurry was substituted from 0% to 25% by mass of cement with an increase of 5% in each substitution. Water/cement ratios of 0.4 and 0.5 were used in the mix design. Concrete cubes and beams were casted to test the strength and durability of the concrete. Concrete's compressive and flexural strength were lowered marginally, but its pull-off strength was boosted by up to 15% when Kota stone slurry was substituted.

A. Hussain, 2015, studied the problems occurring due to the waste generated from the stone mining industry, and possible solutions to this problem were examined. The total stone production of India is 185 million tonnes per year which shares around 32% share of the global stone production. Only Rajasthan produces the 90% portion out of the country’s total stone market.

As per the study done by **Rajani Lakhani et al, 2014**, the stone is a very useful building material. Various types of stone like marble, granite, limestone, slate, etc can also be used for construction purposes. Kota stone is nothing but a variety of flaggy limestone in a fine-grained state which is rich in lime so it is used for construction purposes. Waste generated is mainly due to two sources mines and polishing units.

3. Materials and Methodology

3.1 Raw Materials

3.1.1 Cement

Cement is binding material used to prepare concrete mix. Cement is industrial material developed by mixing calcareous material at high temperature in kiln. Cement factories are established where the raw material is easily available to prepare cement.

3.1.2 Coarse Aggregate

Crushed stone is most commonly used as coarse aggregate in cement concrete mix. Two different sizes of coarse aggregate were taken, 10 mm and 20 mm. Particle distribution of coarse aggregate (10 mm and 20 mm) confirms IS code 383-2016. Locally available crushed stone from Jaipur quarries is done.

3.1.3 Natural Sand

Natural river sand is most commonly used as fine aggregate in cement concrete mix due to their particles are rounded with finished surface texture. Fine's aggregate should be well graded as they generated maximum packing and fewer voids in concrete.

3.1.4 Manufacturing Sand (M-Sand)

Stone dust was obtained from nearby stone cutting site. The gradation and fineness modulus were determined in the lab.

3.1.5 Kota stone slurry

Kota stone slurry was procured in dry form from a local vendor of Kota stone seller in Jaipur. The substitution of Kota stone slurry was from 0% to 25% by weight of cement.

3.1.6 Flexural or Bending strength of concrete

Bending or flexural strength is estimated on beam dimension of 100 mm X 100 mm X 500 mm 27 after 28 days of water curing as per recommendation of Indian standard BIS: 516-1959. Four Point bending machine setup was used to evaluate flexure strength of samples.

Flexural or Bending strength=□□/□□2
Where
P = Ultimate fracture force
L= Length of beam from supports

3.1.7 Splitting Tensile Strength on concrete

Tensile strength of cement concrete is evaluated by splitting sample in two halves. Tensile strength 28 is important to find as concrete is weak in tension so if replacement weak the sample, then it's difficult to use. Cylindrical specimen of 150mm diameter and three hundred, mm height was used to examine splitting tensile strength as stated in recommendation of Indian standard BIS: 516-1999 after twenty-eight days of water curing.

3.1.8 Water absorption

Specimen cubes of size 100mm were casted and immersed in water for 28 days curing. Specimens were kept at temperature of 110 ± 5°C in oven for 24 hours. Each specimen were taken out from the oven and allow it to cool up to room temperature. Measure dry weight of specimen. Repeat this process until the difference between two consecutive 24 hours weight is less than 0.5 % of the larger value.

Ultrasonic pulse velocity

To verify the integrity and quality of concrete, a non-destructive technique of ultrasonic pulse velocity (UPV) on the cubic specimen of 150mm was performed as per ASTM C597 (2002).

4. Results and Discussions

Compressive Strength

Table 4.1: Compression Strength of various mixes

Sand Type	Mix No	Kota Stone Slurry (%)	Compressive strength (N/mm2)	
			7 days	28 days
Natural Sand	N-K0	0	35.5	47.8
	N-K5	5	37.4	48.9
	N-K10	10	38.2	50.2
	N-K15	15	39.7	53.1
	N-K20	20	36.2	49.2
	N-K25	25	33.6	46.4
	M-K0	0	33.9	45.6
	M-K5	5	34.5	46.1
	M-K10	10	35.9	49.8
	M-K15	15	38.6	51.3
	M-K20	20	36.3	47.4
	M-K25	25	34.2	44.3

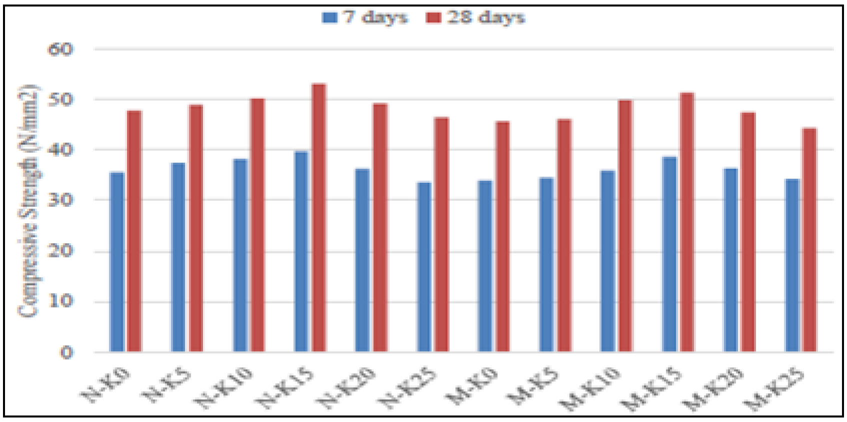

Figure 4.1: Compressive Strength v/s % of replacement after 7 and 28 days

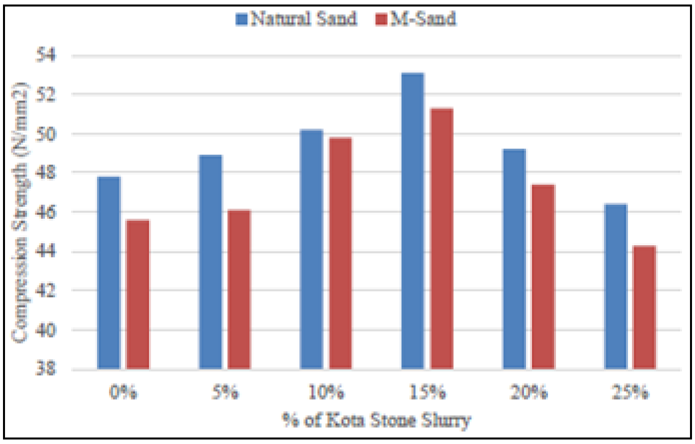

Figure 4.2: Variation in Compressive Strength for different material

4.1 Flexural and Tensile Strength

Flexural and tensile strength for all twelve mixes is inspected after 28 days of water curing. Outcomes of flexural and tensile strength are displayed in table 4.4. Outcomes follow similar trends to compression strength results.

Table 4.2: Flexural strength for different mixes

Sand Type	Mix No.	Stone Slurry (%)	Flexural strength (N/mm2)	Split Tensile Strength (N/mm2)
Natural Sand	N-K0	0	4.72	3.75
	N-K5	5	4.89	3.81
	N-K10	10	4.92	3.88
	N-K15	15	5.11	4.11
	N-K20	20	4.88	3.73
	N-K25	25	4.72	3.62
M-Sand	M-K0	0	4.66	3.68
	M-K5	5	4.74	3.75
	M-K10	10	4.92	3.89
	M-K15	15	5.05	3.97
	M-K20	20	4.79	3.69
	M-K25	25	4.61	3.61

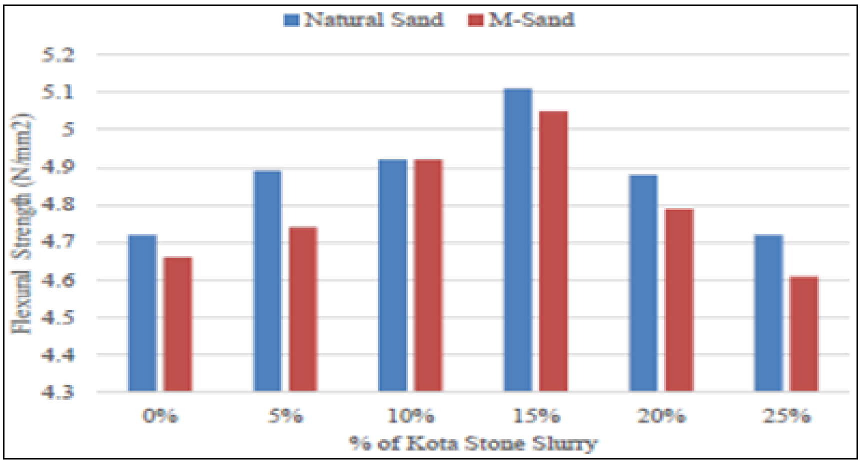

Figure 4.3: Variation in Flexural Strength for different material

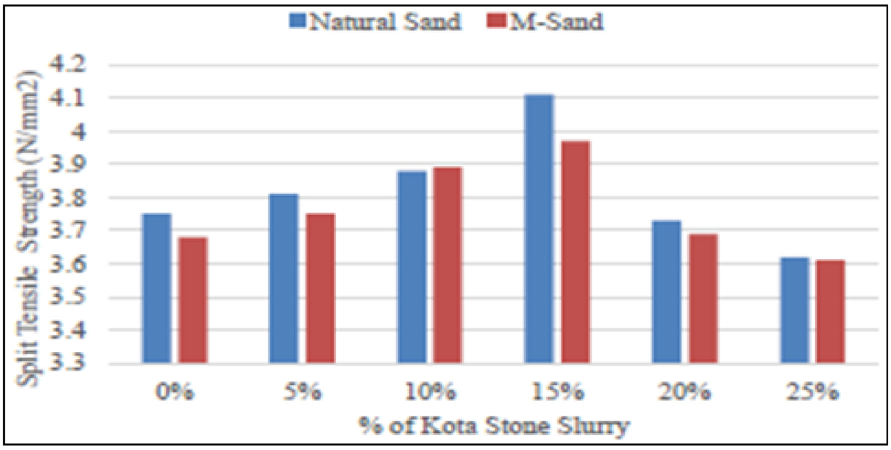

Figure 4.4: Variation in Tensile Strength for different material

Table 4.3: UPV values for different mixes

Sand Type	Mix No.	Stone Slurry (%)	UPV (km/s)
Natural Sand	N-K0	0	3.824
	N-K5	5	3.912
	N-K10	10	4.016
	N-K15	15	4.248
	N-K20	20	3.936
	N-K25	25	3.712
M-Sand	M-K0	0	3.648
	M-K5	5	3.688
	M-K10	10	3.984
	M-K15	15	4.104
	M-K20	20	3.792
	M-K25	25	3.544

5. Conclusion

The requirement of SP dosage is increasing with the increase of replacement percentage. Whereas M-sand concrete mixes requires higher SP dosage compare to natural sand mixes.

Utmost compressive strength is achieved in N-K15 and M-K15 mixes are 53.1 MPa and 51.3 MPa respectively. This increment was observed due to the pozzolanic nature of the Kota stone slurry. Kota stone slurry behaves like supplementary cementitious material.

Maximum flexural and tensile strength was achieved by N-K15 and M-K15 mixes. In contrast, the maximum level of replacement strength is substantially reduced. Rises in flexural and tensile strength are due to the higher angularity and filler effect of Kota stone slurry. Improved ITZ is visible in mixes that contain Kota stone slurry.

A similar phenomenon was observed for permeability outcomes of all mixes. There is a substantial reduction to 15 % of replacement after that rise in depth of water penetration observed.

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