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# Sustainable Utilisation of Kota Stone Slurry Waste in Cement Mortar

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**ABSTRACT:** Kota stone waste is main source of one of limestone which is found in Kota, Chittorgarh and Jhalawar districts of Rajasthan. Kota stone waste is very fine in nature and siliceous calcium carbonate rock of sedimentary rock in nature. A huge amount of waste was generated while cutting and polishing of Kota stone waste and further this waste is known as Kota stone cutting and polishing waste. Immediate disposal of huge amount of generated waste from Kota stone industries will be beneficial for our environment. Due to this various environmental problem like bronchial, vision and skin disorders in the local people is very common. This thesis presents the study of mortar mix using Kota stone slurry as a partial replacement for sand. The replacement has been done partially in various proportions, and its effect on properties of mortar is studied. The work has been carried out on PPC (fly ash based) grade cement, and the river sand has been substituted by Kota stone slurry from 0 to 100%. For all mortar mixes, compressive, flexural, split tensile strengths, ultra-sonic pulse velocity, Resistance to chemical attack, Adhesive strength and water absorption capacity have been determined. From the study it is observed that compressive, flexural and tensile strength enhances for up to 50% substitution. And in case of acid and sulphate resistance, optimum performance of mortar shows at 30% Replacement whereas, water absorbing capacity increases continuously up to 100% substitution of sand by Kota stone slurry waste in cement mortar mixes.

**KEYWORDS:** Kota stone, Limestone, PPC, Ultrasonic Pulse Velocity, Sedimentary Rock.

## I. INTRODUCTION

The increasing demand of fine aggregate to provide the infrastructural need has led to a shortage of it in various countries. Uncontrollable taking out of fine aggregate (sand) from river beds has triggered a significant risk to society and Environment. That huge amount of extraction of sand has given rise many problems such as disturbed aquatic lives, dropping water table, loss of water retaining sand layers, expanded river courses and side sliding, vegetation deficit, exposed intake wells of water supply schemes. Due to an adverse effect on the environment, prohibition on fine aggregate (sand) exploitation has introduced in many states all over the country. The shortage of availability of sand and also available in higher price that may increase the final cost of construction. So overcome this problem researcher all over the world trying for some alternative solution so, existing waste material can be used in place of river sand in construction sector.

State Rajasthan is very well known for unlimited sources of many kinds of stones. For example, marble, granite, limestone, kota stone, dholpur sand stone etc. One of major well-known industry is Kota stone industry situated in Rajasthan being their vibrant colours and smooth texture. They find their usability for decorative purposes in houses and offices. India holds a huge amount of calcareous assets. Around over 85,600 MT (million ton) of calcareous stones stores including various stones as discussed above. Approximate manufacturing of calcareous stones is 188.6 MT per annum (Jayesh Kumar Pitroda et al, 2013). Kota stone waste extraction areas near by Kota district are free from sandstone coverings, and the whole shape comprises of various positions of limestone beds. The normal production of satisfactory characteristics of Kota Stone per hectare land area is about 1.0 lakh million ton. Also, if we go with this existing trend of yearly manufacture level, 55 to 60 hectare land is carried under stone mining every year. Kota stone waste is a specific kind of limestone produced in Kota district as well as nearby areas. Although various type building stones are available but Kota stone dominates or holds a sole place in Indian construction sector. From the ancient time in India Kota stone is very popular and due to its attractive patterns, pleasing colors and designs enhanced its importance in many significant places such as churches, temples, mosques, palaces, monuments, etc. as an ornamental and decorative stone. The appearance, strength and structural soundness of Kota stone is readily affected by the natural forces as well as changes in climatic conditions. Kota stone is

vulnerable to acidic agents and even a low strength acid can change its properties. Though, the definite results of acidic exposure may differ with the nature of the acid.

Due to the above reasons demand of Kota stone is increasing with a very high rate and this led to the generation of enormous amount of Kota stone waste in the form of solid waste and slurry waste. Stone wastes are generated through the activity of cutting and polishing in the form of overburden, screening residual and stone fragments. Approximately through mining activity around 175 MTs of quarrying waste is created every year.



Fig. 1. (a) and (b) Kota stone cutting waste

Because of huge amount of consumption in many relied construction activities and related contrary effects, availability of natural sand (river sand) in the state and country is lessening. This type of problem earlier been stated in many African and European countries. Careful use of natural resources is mainly directly related to economic development of that region. Thus, the utilization of Kota stone waste slurry as the partial substitution of sand may prove advantageous for mining and construction both industries.

The utilization of stone slurry of marble, granite, limestone etc as a construction material has been studied in recent years. Literature survey recommends that stone slurry be able to effectively utilized as building material. Detailed literature survey reveals that only few studies has been published on the use of lime stone slurry waste in cement mortar in place of sand. Even though available studies designate, enhance properties with supplement of lime stone waste in mortar but because of absence of complete studies on use of this lime stone slurry waste in cement mortar, it fails to make a strong interpretation between its users. Stone wastes are locally available their consumption can be enlarged consuming them in place of sand in mortar. So, there are very few researches is available on efficient utilization of slurry waste, which was produced due to cutting and polishing of Kota stone. Furthermore, due to the limited availability in areas such as Kota, Jhalawar and Chittorgarh restricts the complete study of its use in Mortar.

### Objectives

Basic intention is constructive utilization of Kota stone slurry waste in cement mortar in place of sand. However present investigation has been aim to achieve following objective:

- To study the physical property of materials using in mortar.
- To study the compressive, tensile and flexural strength behaviour of mortar with kota stone slurry replacement in place of sand.
- To study the homogeneity and voids in mortar beam.
- To study the durability of mortar against acid and sulphate attack in mortar with kota stone slurry replacement in place of sand.
- To study the pull off strength of mortar when used over bricks.

### II. RELATED WORK

Pervious concrete and its development by using different construction materials. His findings included durability, mechanical and physical studies, in addition to clogging effects Elango et al., (2021) From his study, it was



established that pervious concrete is an environment favorable material and can be used as a pavement material in parking lots, pedestrian walkways, swimming pool areas, driveways and low volume traffic areas.

AlShareedah & Nassiri, [1] conducted various laboratory experiments and studied the mechanical and hydrological performance of pervious concrete, like porosity and permeability, abrasion resistance, compressive and flexural strength and their interrelationship. He also studied the impact of stone waste, alternative binders, additives and fillers, and natural fibers. He evaluated particularly stone waste and found that they showed increase in flexural and compressive strength by up to 37% and 25% respectively.

Zhong et al., [2] studied the application of pervious concrete as a part of practical research. He laid prominence on micro structural pore system characterization (PSC) and its effects on the hydraulic, acoustic and mechanical properties of pervious concrete.

Sarvesh P.S. Rajput [3] Investigated crushed stone dust as fine aggregate of cement concrete. According to the Indian Standard Specification, natural sand (NS) is used and different proportions of crushed stone dust (CSD) are used instead of NS sand to prepare the standard mix of M20 and M30 cement concrete. For each mix, the slump cone test, compaction factor test, density test, compressive strength test and ultrasonic pulse velocity test were performed. The research results show that the strength performance of cement concrete using gravel sand is better and more uniform than conventional concrete. Studies have shown that crushed stone powder can be used as ready-to-use solid waste and as a substitute for natural sand in cement concrete construction projects, which can reduce material costs and construction costs and help repair environmental problems. Rana et al., [4], conducted a study with the utilization of dimensional limestone as fine aggregate in the production of concrete. For that around twenty-six mixes were casted including control mix were tested by substituting fine aggregate with crushed sand (CS), slurry and manufactured sand (MS). From the obtained results it can be concluded that MS was used blending crushed solid stone waste (85%) and slurry (15%) can be effectively used as fine aggregate. Concrete casted with MS found various better performance in terms of greater strength, decrement in bleeding, waster permeability and lesser void formation. The very beneficial utilization of MS in concrete can be understand that it can be fully substitute with natural sand. Goncalves et al., [5] it was found that the decrease in strength can be attributed to the lower packing density and the greater influence of the interface transition zone. Conversely, if the cement content of each design mix remains the same, the percentage of fine particles will increase. There is simply not enough paste to cover all the fine and coarse particles, which reduces the compressive strength.

### III. METHODOLOGY

#### Flow Table Test:

This test is used to determine the workability and to find out the suitable water- cement ratio for mortar. Workability is the ease with which the mix can handled. different trail have been performed to manage the suitable flow value of 210 mm.

#### Compressive Strength Test:

Compressive testing machine (CTM) has been used to find out compressive strength of mortar cubes of 50 mm size. Compressive strength of specimens has been calculated on 7 and 28 days of curing. The working temperature of the adding water, humid closet or moist room and cubes were kept at set  $23 \pm 2^\circ\text{C}$  water temperature in the storage tank. The comparative humidity level in the laboratory should be maintained to a level not less than 50%

Compressive strength by following formula:

$$f = P/A$$

Where;

f = Calculate compressive strength (MPa) P = Applied maximum load in N,

A = Surface area cube sample in  $\text{mm}^2$ .

#### Flexural Strength Test:

The centre point loading method is used in making flexural test on specimen. The device is planned in such a way that only vertical forces are directed to the specimen only without considering any eccentricity. Three specimens have been prepared for each proportion and each period of test specified. The maximum load showed by the examining machine is noted and flexural strength (for specified size of specimen and conditions) in MPa as develops:

$$K = 0.0028S$$



where;

K = Flexural strength in MPa and  
S = Highest load in N.

**Tensile Strength Test:**

The tensile strength test of hydraulic cement mortars is determined by conducting a test using briquette specimens.

**Ultra-sonic pulse velocity test:**

This test can be performed on the same material repeatedly without negative impact on the material itself, and also the future usefulness of the material is not affected.  $V = L/T$

Where:

V= Ultra sonic pulse velocity (m/s),

L= distance between transducers faces in meter (16cm), T= time taken to travel the length L (Transit time).

**Adhesive strength of mortar on masonry units:**

Three specimens were prepared of plastering the mortar on the brick surface with a depth of 10mm for each mortar mix. After 24 hours the specimens were enclosed within an air tight covering for 7days at a temperature of  $20 \pm 2$  °C until 28 days and tested age of 28 days after removing from the storing atmosphere. Pull heads were glued and tensile load was applied.

**Acid and sulphate resistance:**

Three specimens of 50mm cube have been prepared for each type of mix for a particular period of time. The changes in weight and compressive strength have been observed in the medium of Sulfuric acid and magnesium sulphate after 7 days, 14 days and 28 days. Specimens have been kept in chemical exposure of amount 3% of quantity of distilled water.

**Water absorption test:**

Water absorption after immersion % =  $[(B - A)/A] * 100$  where;

A = Mass of oven-dried sample in air (g).

B = mass of surface-dry sample in air after immersion (g).

**IV. EXPERIMENTAL RESULTS**

Gradation of river sand (RS) and Kota stone slurry (KSS) from which it can be pointed out that KSS is finer than RS. It can be said that mortar with combination of KSS may give better packing resulting into greater compressive strength

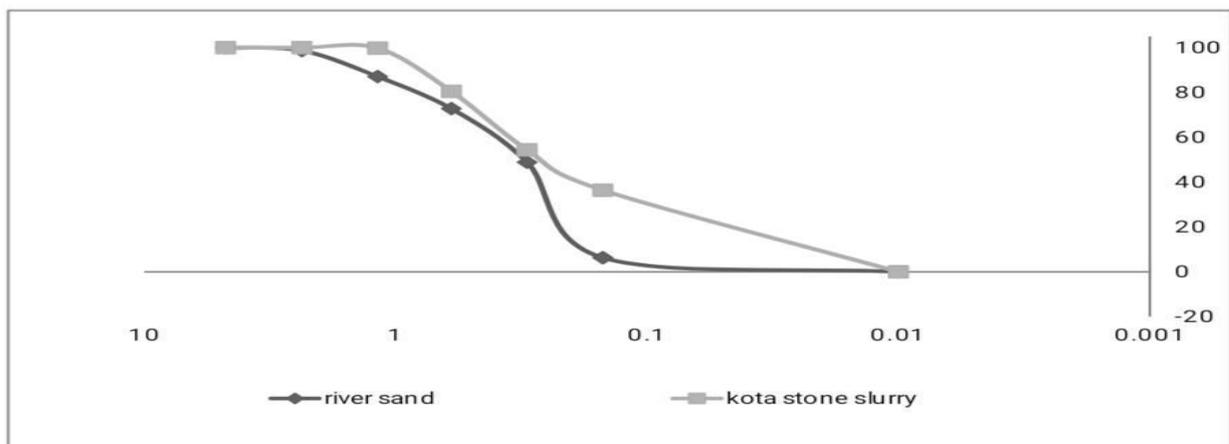


Figure 3.1 Gradation of river sand, kota stone slurry, and kota stone crushed sand

It can be observed from graph that initially w/c ratio decreases up to 30% replacement of sand by Kota stone slurry. It is because of domination of thixotropic property of Kota stone slurry which increases the workability of



mortar mix. But after 30% replacement of sand by Kota stone slurry, w/c ratio increase which is due to the domination of fineness property of Kota stone slurry because workability is inversely proportional to the fineness.

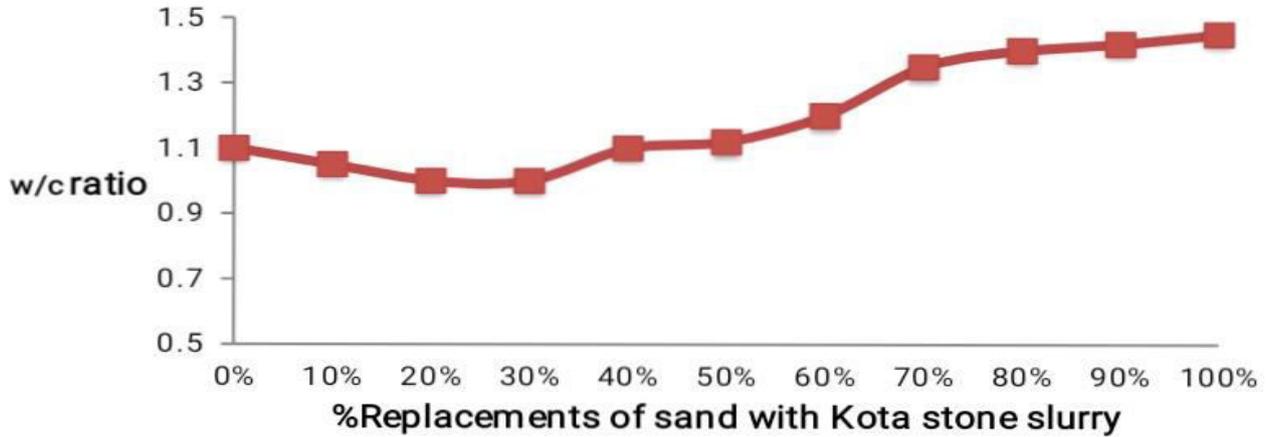


Figure 3.2 Variation of w/c ratio with % substitution of sand with Kota stone slurry

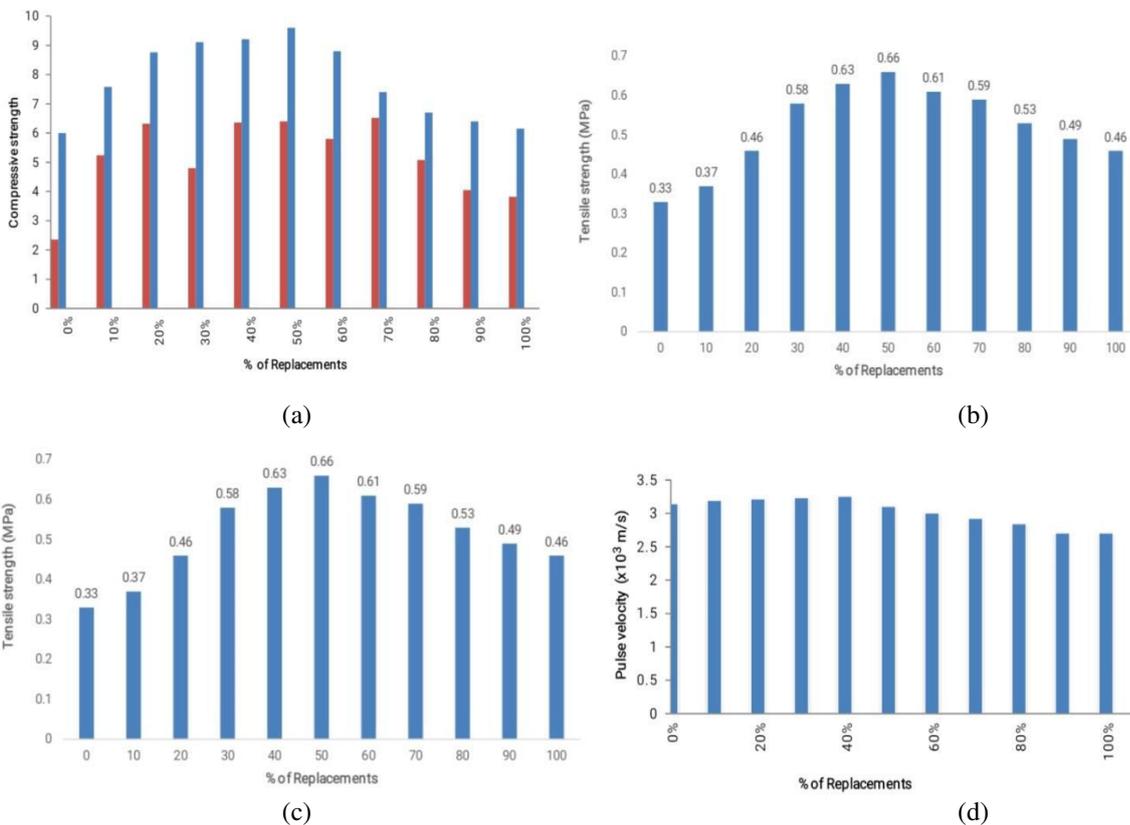


Figure 3.3 Effect of Kota stone slurry on (a) compressive strength, (b) Flexural strength, (c) Tensile strength, (d) Pulse Velocity

Maximum compressive strength at 7 days & 28 days is obtained for 50% replacement of sand with Kota stone slurry because as water content decreases, compressive strength increases. Compressive strength at the age of 28 days increases from 6Mpa at control mix to maximum of 9.6Mpa at 50% Replacement. It is observed from the graph that the flexural strength at 28 days is maximum for 50% replacement. As water content decreases, the flexural strength increases.

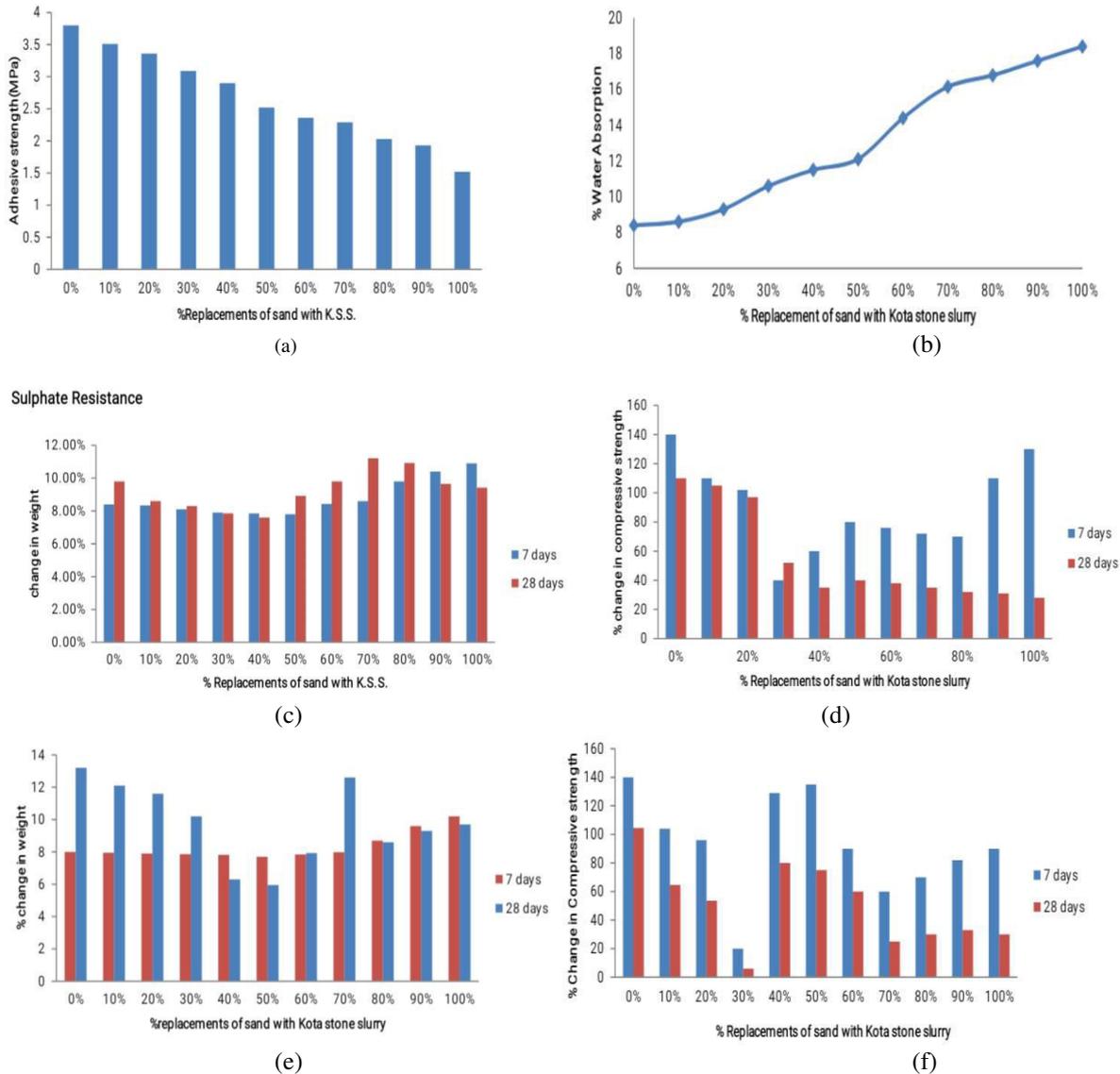


Figure 3.4 Effect of Kota stone slurry on (a) Adhesive strength, (b) water absorption, (c) Percentage weight change v/s Percentage Replacement in sulphate medium, (d) Percentage compressive strength change v/s Percentage Replacements in sulphate medium, (e) Percentage weight change v/s Percentage Replacement in Acidic medium, (f) Percentage compressive strength change v/s Percentage Replacements in Acidic medium.

Axial tensile strength at 28 days is maximum for 50% replacement, Tensile strength of control mix mortar is 0.33 Mpa and by increasing upto 50% it attains the maximum value of 0.66 Mpa then decreases continuously. Ultrasonic pulse velocity is maximum for 40% substitution of sand with Kota stone slurry. As the amount of Kota stone slurry rises up to 40%, the gradation improves and porosity decreases.

The adhesive strength of mortar for 10% Kota stone slurry is 90% that of control mix because increment in Kota stone slurry makes the mix porous. Incorporation of Kota stone slurry has diminished the vulnerability of mortar mixes when subjected to a sulfate solution. These are due to the increment in porosity with Kota stone slurry. Mortar mix with 30% replacement achieve better result by decreasing the susceptibility to attack by sulphate solution.



## V. CONCLUSION

This study, the Kota stone slurry has been used in place of river sand in Mortar of 1:4 Cement and sand. Total 11 mixes have been prepared with substitution of Kota stone slurry instead of Sand at 0%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% and 100%.

- Initially as the quantity of Kota stone slurry enlarges up to 30%, gradation enhances and workability increases so maximum water can be saved by 30% substitution of sand with kota stone slurry.
- Due to increasing quantity of Kota stone slurry, compressive strength, flexural strength and tensile strength at 28 days increase continuously up to 50% and then decreases.
- The adhesive strength of mortar in masonry is maximum at control mix and then decrease continuously up to 100%.
- Because of the higher water absorption capacity of Kota stone slurry in comparison to the river sand the slurry combined mortars absorb additional water than conventional river sand mortar.
- With the consideration of the durability front, 30% of sand substituted by Kota stone slurry seems to be a more stable mortar mix. The modification in compressive strength is lesser when associated with control mortar when exposed to hostile surroundings. This supports the utilization of this mortar in environments where acidic or sulphate rich soils are available for building the masonry foundations and in manufacturing and industrial areas where pollutants are existed at frightening stages.

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