# Review Paper on Partial Replacement of Natural River Sand by Industrial or Mining Waste in Mortar

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**Abstract -** *Natural river sand (NRS) is the main fine aggregate being used from long time now. Supply of NRS is getting banned in many parts of country like Maharashtra and Rajasthan as the sources are being depleted and it is illegal as well. Hence it is necessary to replace NRS as fine aggregate. There is also need of making construction industry sustainable, which can be done by utilizing waste from other industries or some mining waste, as some construction material. There are many potential wastes which can be utilized as NRS replacement like granite dust, marble powder, recycled masonry aggregate, recycled high impact polystyrene, grit residues, etc. This NRS replacement must not adversely affect the strength & properties of the mortar. Therefore, this paper presets the review of some research paper, in which there is replacement of Natural River Sand in mortar by any industrial or mining waste. Research in this field and positive results from their work are important to study & implement further for making construction industry sustainable.*

***Key Words***: sustainable mortar, sand replacement in mortar, mining waste, granite dust, sustainable construction material, marble powder

## 1. INTRODUCTION

The need to substitute Natural River Sand (NRS) as a fine aggregate is growing by the day. The provision of NRS is being outlawed in many sections of the country as its sources are low, and it is also illegal. On the other hand, there are many waste materials like granite dust, marble powder, recycled masonry aggregate, recycled high impact polystyrene, grit residues, etc. and their quantities are increasing day by day. Almost all that mentioned, are non-bio-degradable. As a result, proper garbage disposal is critical. Construction might become more sustainable if this type of waste is used in the construction industry as building materials. Incorporating such garbage into building materials is a great and cost-effective method because it reduces the need of natural resources like sand. The use of waste materials in civil construction is becoming increasingly popular since it provides a proper destination for trash, minimizes environmental concerns, and saves money by replacing old pricey materials with useless wastes.

Several waste products have been used in the past to substitute sand in mortar mixes in order to make the construction industry more sustainable and reduce the impact of waste on the environment. For example, recycled masonry aggregate is used to replace sand in mortar.

## 2. LITERATURE REVIEWS

André Luis de Oliveira Júnior, Leonardo Gonçalves Pedroti et al. [1] tested Grit residues produced during the Kraft process for producing cellulose, as potential sand replacement. Sand replaced mortar was tested for flowability, compressive strength, flexural strength & adhesive strength.

The sand replacement percentages of 10%, 15%, and 20% were examined. The use of grits residue instead of sand, reduced the flow values of the mortars. The reason for this was because the rate of absorption of the residue was faster than that of the sand. The flow index of ecological mortars with a 20% replacement ratio was found to be around 4% lower than the flow index of conventional mortars. The compressive strength of ecological mortars was higher than that of conventional mortars. It was able to deduce from the reported results that replacing 15% of the sand with residue was the best-case scenario. The compressive strength of these mortars after 28 days was 27.4 percent higher than that of standard mortars.

The flexural strengths of the ecological mortars were not significantly different from the reference mortar's flexural strength. The tensile bond strength of the mortar with 15% fine aggregate replacement by grits was 35.1 percent greater than that of the reference mortar. This was owing to the residue's propensity to fill up spaces between cement grains, hence increasing the number of solid-particle contact points.

Enrique Fernández Ledesma, José Ramón Jiménez et al. [2] investigated construction and demolition debris, namely masonry waste composed of red bricks and attached mortar, for sand replacement. 25%, 50%, 75%, and 100% sand replacement (by volume) was tested for various properties. M10 mortar (compressive strength = 10MPa) used for testing. Bulk density, occluded air content & workable life of fresh mortar with above mentioned replacement %, were evaluated by authors. Bulk density at 28 days, compressive & flexural strength, shrinkage, adhesive strength, capillary water absorption, resistance to sodium-sulphate attack, leaching were evaluated for hardened mortar by authors.

Because recycled masonry aggregates had a lower dry density than natural sand, the bulk density of fresh and hardened mortars dropped linearly as the use of recycled masonry aggregates increased. The use of recycled sand in mortar manufacture is not restricted in any way. For replacement ratios below 75 percent, there were no statistically significant variations in the mean values of the occluded air content, albeit the mean values did indicate a linear decrease as the replacement ratio grew.

For replacement ratios greater than 25%, the mean values of workable life exhibited statistically significant variances. When recycled sand is used in new mortars, its usable life is reduced linearly. Although all mortars with replacement ratios up to 50% exceeded the value of 10 MPa in the compressive strength test at 28 days of curing, the mean values of compressive and flexural strengths declined linearly as the recycled masonry aggregates content increased. The mechanical strength of all the mortars increased over time. As the curing time rose, the disparities between the mean values of the mechanical strengths of the reference mortar and mortars with replacement ratios below 50% declined, reaching a minimum at 180 days. Due to the dispersion of findings in the pull-off test, the mean values of adhesive strength indicated no statistically significant differences with replacement ratios below 75%. As the percentage of recycled masonry aggregates rose, the mean values declined linearly. For replacement ratios more than 25%, the mean values of capillary water absorption exhibited statistically significant differences. As the percentage of recycled masonry aggregates rose, the mean values climbed linearly. Mortars containing recycled ceramic aggregates lost more weight after 10 cycles of immersion in sodium-sulphate solution than the control mortar, despite no evident damage. The results were superior to those of other writers who employed recycled concrete aggregates.

K.I. Syed Ahmed Kabeer, Ashok Kumar Vyas [3] investigated marble powder as potential sand replacement. 1:3, 1:4, 1:5 and 1:6 mortar proportions were tested for replacement of sand from 0% to 100%. Workability, fresh bulk density, drying shrinkage, compressive strength, tensile bond strength between brick & mortar, adhesive strength, density, water absorption were evaluated for mortar with all the above-mentioned replacement % of sand. Marble powder's thixotropic feature reduces the water demand of all mix proportions when used in place of river sand at a substitution level of 20%. Because of the lower water content and marble powder's potential to speed up the hydration of $C_3S$ and the synthesis of calcium carbo-aluminates with $C_3A$, a denser microstructure has resulted. The mortars' mechanical performance has been enhanced as a result of this.

The compressive strength of mixes including 60% marble powder in place of river sand is comparable to that of the control mortars. The addition of marble powder to lean mortar mixes, in particular, improves bond and adhesive strength significantly. Because marble powder has a greater specific surface area, the drying shrinkage of mixes containing 20% marble powder is nearly identical to that of control mortars. Despite the fact that these mixtures include less water than traditional cement sand mortars, they perform well. The water absorption of mortars containing 20% marble powder differs just slightly from that of control mortars. Porosity values show a comparable range of variation.

Lalit Kumar Gupta, Ashok Kumar Vyas [4] investigated granite dust as potential sand replacement. 1:4 and 1:6 proportions were used and 30% and 40% replacement of coarser sand by granite dust was done. Flow table test, compressive strength test, ultra-pulse velocity & dynamic modulus of elasticity, tensile bond strength test, adhesion test, test for water absorption & voids, drying shrinkage test, microstructure analysis was conducted on mortar with above mention sand replacement %age. Due to the angular and abrasive texture of granite powder, the workability of mortar with it diminished, and a higher percentage of water was added to reach the needed flow value. However, due to proper grading attained with a mixture of coarse sand and granite powder, the w/c ratio of granite powder mortars was lower than that of the control mortar (FS).

When the volume of granite powder was 40% of the raw fine aggregate, the compressive strength was the maximum. Because of the lower w/c ratio and the filler effect of granite powder in blended mortar, the value increased. Although the compressive strength of mortar is not the only significant criterion for evaluating performance, it is the only specification accessible in standards. The bond strength of mortar with 30% natural sand replacement by volume had demonstrated to be the best for usage in brickwork. The binding strength of the mortar with 40% natural sand replaced by volume was lower than that of the mortar with 30% granite powder, but it was still higher than that of the control mortar. As a result, masonry operations were best served by mortar containing 30% granite powder. Mortar made with 40% granite powder had the highest adhesion strength. The bonding between mortar and substrate determines the adhesion strength of a mortar, and the bonding is heavily influenced by the pores present. The usage of fine granite powder improved bonding, resulting in increased adhesion strength. The shrinkage of mortar rose as the percentage of granite powder replaced by natural sand grew in a drying shrinkage test. However, a mortar made with 30% granite powder performed similarly to the control mortar (FS). The drying shrinkage was substantially larger at 40% replacement level.

The water absorption and permeable voids of the granite powder mortar were lower than those of the control mortar. The results obtained for compressive strength, ultrasonic pulse velocity, and dynamic modulus of elasticity are reflected in this effect for water absorption and permeable voids. SEM, FTIR, and XRD were used to investigate the microstructural variation of mortar. Incorporating granite powder into the mortar mix resulted in better pore packing. Si-O-Si polymerization dominates Si-O-Al cross linking, according to FTIR and XRD. This aids in the enhancement of the strength of granite powder mortar mixtures.

Ru Wang, Christian Meyer [5] investigated recycled high impact polystyrene (HIPS) as a sand substitute in cement mortar. The percentage of sand replacement was evaluated at 10%, 20%, and 50%. Flow table test, compressive & splitting tensile strength test, dynamic modulus of elasticity, thermal conductivity, water vapour permeability & resistance to freeze and thaw were evaluated for mortar with above mentioned sand replacement %age. By replacing sand with HIPS, the compressive and splitting tensile strengths of mor-tar are reduced, however the splitting tensile strength reduction is significantly smaller than the compressive strength loss. Compressive strength is reduced by 12 percent, 22 percent, and 49 percent in mortars containing 10 percent, 20 percent, and 50 percent HIPS, respectively. For mortar containing 10%, 20%, and 50% HIPS, however, the splitting tensile strength is reduced by 1.5 percent, 11%, and 20%, respectively.

When the HIPS content of the mortar grows, the failure type becomes more ductile, and the maximum strain increases significantly to 1.1, 1.2, and 1.8 times that of conventional mortar when the HIPS ratio is 10%, 20%, and 50%, respectively. HIPS also improves the amount of energy dissipated per cubic metre of mortar. When the HIPS ratio is increased from 0 to 10%, 20%, and 50%, the dynamic modulus of elasticity of mortar is observed to fall from 36 GPa to 30 GPa, 25 GPa, and 13 GPa, respectively. The dry bulk density of mortar is reduced via HIPS. The mortar qualified as medium weight concrete with 10% and 20% HIPS replacement, and it qualified as light weight concrete with 50% HIPS replacement. When the HIPS ratio is 10%, 20%, or 50%, the thermal conductivity of the mortar drops to 87 percent, 69 percent, and 44 percent of that of conventional mortar, respectively. HIPS reduces the water vapour permeability of the mortar but has no effect on the freeze–thaw cycle resistance. The usage of mortar containing varying percentages of HIPS shows potential for use as medium or light-weight concrete, owing to its better thermal insulation and the addition of value to a post-consumer plastic material that is now classified as solid waste.

L.G. Li, Y.M. Wang et al [6] investigated Granite dust as sand replacement & used it as paste replacement and cement replacement for reducing the cement and sand consumption. In paste replacement it would work as filler material. They established that paste replacement was better alternative. SEM & XRD test, test for optimum superplasticizers dosage, flow spread test, cube compressive strength test were conducted on mortar containing granite dust and sand. Overall, the test results showed that using GD as a paste replacement might lower cement content by up to 25% while increasing cube strength by roughly 12%. On the other hand, assuming the cube strength is not compromised, the previous method of using GD as a cement replacement could only reduce the cement content by around 5%.

The GD is predominantly made up of SiO2, Al2O3, CaCO3, and Ca $(OH)_2$, and has a gap-graded particle size distribution and an angular form. Using GD as a paste replacement and GD as a cement substitute would both cut the cement content of mortar significantly. An addition of GD up to 15% by volume of mortar would lower the cement content by 25.0 percent in the case of paste replacement, and an addition of GD up to 15% by volume of the initial cement content would reduce the cement content by 15.0 percent in the event of cement replacement. Using GD as a paste substitute would raise the SP dosage required to achieve the desired workability, whereas using GD as a cement replacement has little impact on the SP dosage required. Using GD as a paste replacement would improve the microstructure of the hardened mortar greatly, whereas using GD as a cement replacement would cause significant microstructure damage due to an excessive rise in the effective W/C ratio.

## 3. CONCLUSIONS

Supply Natural River Sand is getting banned in many sections of India as it is illegal & the sources are being depleted day by day hence, there must be some sound replacements for NRS. According to all the reviewed papers, there are many good replacements like granite dust, marble powder, grit residues, recycled masonry aggregate, recycled high impact polystyrene. Some of them like recycled masonry aggregate, granite powder etc requires higher amount of water for maintaining required workability. In some cases, the finer material like marble powder acting as filler between the voids and hence increases the compressive strength of the mortar. In some cases, sand replacement is not increasing strength but giving somewhat lesser strength than mortar without NRS replacement. It can be concluded that 20 – 30% replacement of NRS by industrial or mining waste is possible without affecting the compressive strength & other properties of the mortar.

## ACKNOWLEDGEMENT

I am very thankful to all the researchers whose research papers are referred in this study and for helping me to carry out review of the topic, I would like to thank Dr. Rajul K. Gajjar & Prof. Poonam I Modi for their unceasing support and guidance.

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