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A state of the art of partial replacement of cement & fine aggregate by using different sustainable materials

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Abstract: The world's natural resource reserves are insufficient to meet long-term demand under the existing system for providing adequate natural resources to create the infrastructure and the emerging system. The discovery of natural material deposits has declined for several materials. Many industrial materials' processed ore, sand mining, and erosion of river grades have been deteriorating over time, which has led to a decrease in material processing yield.

India is a developing country with a rapidly expanding infrastructure and likely excessive consumption of natural resources. In general construction, we can use cement, sand, aggregate (fine and coarse), and water to make concrete. The main ingredients in concrete, cement, and sand are rising quickly and steadily nowadays. Infrastructure such as expressways, powerhouses, metros, industrial structures (yarns), ports, naval yards, and harbors are needed by emerging nations like our country to satisfy the demands of globalization in the development of highways, roadways, airports, buildings, and other structures.

Sand and cement ingredients are required to make concrete, which has become costly and has a limited resource. In light of this, finding an appropriate replacement material for river sand from industrial waste and cement from power plants' waste material is necessary. Many countries have approved the use of granite powder, a natural product, as a construction material, as well as fly ash, coconut shell, and rice husk as partial replacements for cement.

A word Recycling has a unique value in the sense that there is no pollution, no wastage, no other production, and no resource consumption. It avoids wasting potentially usable resources, consumes less energy, lessens the demand for fresh raw materials, and lessens air and water pollution by lowering the need for conventional garbage disposal. Cement, fine aggregate, coarse aggregate, and water are concrete ingredients. To make use of the waste material, quarry dust, fly ash, and coconut shell have been tried as substitutes for the fine aggregate as well as cement.

Keywords – Quarry dust, Fly-ash, river sand, cement, white paper slug, silica fume, copper slag, coconut shell, rice husk, glass power

I. INTRODUCTION

In the construction sector, concrete plays a significant role in the quality and price of the project and also affects the construction. In a particular location, natural sand is not available, which requires the transportation of river sand, which increases the cost of the project, so it is necessary to replace the river sand. Its use as fine aggregate in concrete has increased development costs. This paper describes the search for a cheap, easily available alternative material to natural sand. Some replacement materials, such as glass powder, waste lime, and silica stone dust, have already been partially replaced by river sand in concrete mixes. A lack of the required quality is the main limitation of several of the materials mentioned above. Today, sustainable infrastructure growth requires the use of sustainable resources that meet the technical requirements for fine aggregate and are widely available. On this basis, quarry dust is a suitable option. The wastage related to the quarry is created due to stone crushing, which produces stone dust. This waste has not been recycled in any form. As a result, they are ineffective and contribute to environmental and disposal issues. It is essential to recycle a maximum amount of waste and use a minimum number of natural resources to provide eco-friendly construction. The different material uses in large quantities as soon below.

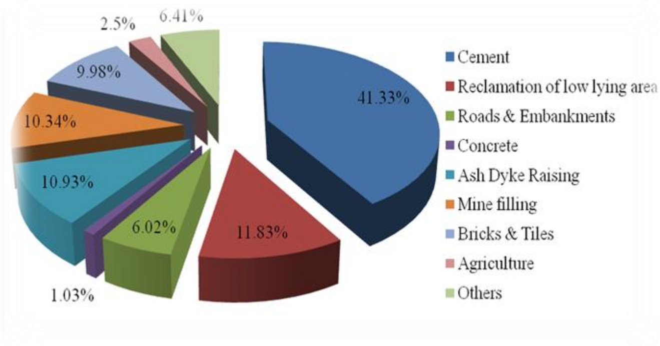


Fig :-01 Material uses in the construction sector

Due to cement's efficiency, adaptability, and economy, it is utilized extensively all over the world. The demand for cement on a large scale has increased daily, and the sources are limited here. Various researchers have also conducted research on replacing cement with other materials, like silica fumes, coconut shells, rice husks, etc. Many scholars noted the effects of the use of fly ash as an additive in cement, an admixture in concrete, and a replacement for cement in concrete. The concrete's compressive strength was evaluated by changing the cement proportions with the right amount of fly ash, and the outcomes were found to be the most efficient.

II. LITERATURE REVIEW

Quarry Dust In this paper scholars Focused on the replacement of natural river sand with industrial sand and quarry dust in cement concrete [1]. Ordinary Portland cement (OPC-43), river sand, quarry dust, and gravel were used as materials for concrete preparation. The concrete design was prepared with a water-cement ratio of 0.43 at a ratio of 1:1.23:2.58. River sand was replaced with quarry sand at 50% and 100%. A compression test, a tensile test, and a bending test were conducted. The concrete blocks were placed on the 7th, 14th, and 28th days of curing. As a result, it has been shown that concrete strength can be achieved by replacing 50% of river sand with quarry sand and industrial sand, which also improves concrete quality.

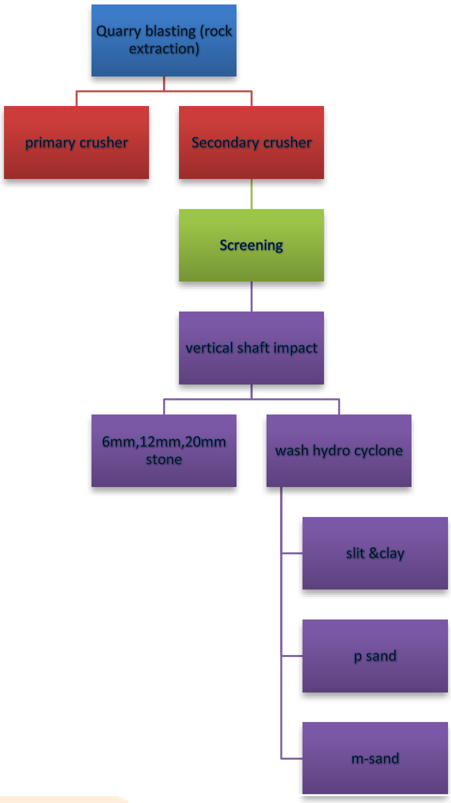
Fig:-02 Natural sand & Quarry dust

In this paper, scholars Use concrete mixed with stone dust as fine aggregate. [2] Aggregate has undertaken research to see which parts of concrete mix proportioning might be influenced by utilizing rock dust partially or completely to replace sand. He discovered that rock dust significantly lowers the workability of concrete while having no effect on compressive strength. He found that, with the right superplasticizer, rock dust can be used as fine aggregate.

In this paper, an experimental study on the use of Concrete stone crusher powder as fine aggregate was discovered. [3] The specimens cast with crusher dust generated about 17% greater compression strength, 7% greater split tensile strength, and 20% more flexural strength than the samples of concrete with natural sand. As per them, the higher strength is due to the jagged corners of stone dust producing a stronger bond with cement than the circular shape of river sand. The RCC concrete beams strengthened with crusher dust withstood around 6% greater load and produced fewer deformations and stresses than that of the beam reinforced with natural sand.

a. Quarry dust with superplasticizers:-

In this paper, they use quarry dust as an alternative to sand. [4] Because quarry dust is non-biodegradable and takes a long time to break down, using it in the building sector decreases the amount of landfill space needed. Quarry dust and natural sand have nearly identical chemical compositions. By contrasting the compressive strength of concrete that has had river sand partially replaced by quarry dust (10%, 20%, 25%, 35%, 40%) with that of concrete cubes of M20 and M25 grades, they determine the effectiveness of employing quarry dust in concrete. Depending on the weight of the cement, a superplasticizer is added to make up for the strength lost via replenishment. The procedures for quarry dust are shown below.



Flow chat:- 01 Procedure for making quarry dust

They researched whether quarry dust could replace river sand in the production of concrete. [5] Quarry dust was used to create M25-grade concrete with a partial sand substitution of 0%, 20%, 40%, 60%, and 80%. Standardized tests were used to assess the specific gravity, water absorption, silt content, and fineness modulus of quarry dust. The strength of the concrete formed from quarry rock dust was then investigated using compression, split tensile, and bending tests on cubes, cylinders, and RC beams.
The outcomes were contrasted with the results of traditional concrete (0%). The findings demonstrated that the strength grew with increasing quarry dust proportions, peaked at a value of 45%, and then dropped in strength and workability.

fig:- 03 Crusher Dust

I. Crushed bricks

In this paper, they perform an experimental investigation on the substitution of sand with crushed brick in concrete. [6] Quarry stone was utilized instead of river sand. Using manufactured sand rather than river sand in concrete saves 40% of the cost. This experiment aimed to evaluate the qualities of crushed brick concrete and to examine different critical aspects of concrete, such as fracture toughness, compressive strength, and split tensile. Crushing bricks mixed with sand to partially replace natural sand. The grade was M25, and the crushed brick proportion was 15%, 20%, and 25% in concrete, which is used in cast cubes, beams, and cylindrical tubes with curing times of 7, 14, and 28 days.

Fig:-04 Crashed brick Particle size

II. Wash Bottom Ash

In this paper, scholars replace the partial amount of natural sand with wash bottom ash. [7] The material strength of special concrete manufactured with a weight-for-weight substitution of washed bottom ash equal to 30 percent of natural sand have an optimal use in concrete to achieve a suitable balance of strength and strong growth pattern over time.

This paper describes the use of fine aggregate as waste Washed Bottom Ash (WBA) in specialty concrete. [8] The WBA is a waste product obtained from an electric generator plant, and the source product is known as bottom ash. Bottom ash was used and totally immersed in water for 3 days to generate WBA with a high carbon content, which was used to replace the quantity of carbon used in concrete. The study's goal is to determine if washed bottom ash may be used in concrete applications and whether doing so is feasible.

The main objective of this research paper is to determine how well-versed construction sector partners are in 25 alternative materials, which were split into five categories because of factor analysis. [9] A survey that the authors created was used to gather data. 140 members of the construction sector from 30 US states and nine Canadian provinces participated in the survey. According to a methodology that considered each stakeholder's level of influence and interest in sustainable building projects, stakeholders.

III. Silica Fume

They optimize the use of silica fume and river sand as a partial substitute for M-sand in high-performance concrete (HPC). [10] The compressive and flexural strengths of concrete mixtures were assessed. Natural sand was substituted with manufactured sand in various proportions (i.e., 10%, 30%, 50%, 70%), and silica fume was added to conventional Portland cement in amounts of 1.5%, 2.5%, and 5%. The findings showed that as the amount of manufactured sand increased, HPC's flexural and compressive strengths increased by about 20% and 15%, respectively. Up to 50% of the synthetic sand used as a sand substitute resulted in a mix strength that was equivalent to the control mix. But when more synthetic sand was added, the strength started to decline.

fig :-05 Silica Fume

IV. Copper slag

Currently, India contributes approximately 7 million metric tonnes of the approximately 35 million metric tonnes of copper slag produced annually worldwide. About 35 to 50 percent of copper slag can be used as a sand replacement to obtain concrete with good strength and durability requirements. In India, CRRI has also tested that copper slag can partially replace sand as fine aggregate in pavement-grade concrete without losing its maximum strength.

Fig :-06 Copper Slag

V. Granulated blast furnace slag

According to a GBFS study, the iron and steel industry generates approximately 15 million metric tonnes of blast furnace slag in the country each year. This waste has been used to replace natural sand by up to 70%.

VI. Wet crusher dust with flyash

About 30 to 35 percent of the total production in each crusher unit is left out as waste material-crasher dust. The ideal percentage of replacing sand with stone dust is 40 percent to 60 percent in compressive strength.

Due to advantages including efficient waste treatment, improved workability, decreased cement consumption, sulfate resistance, greater resistance to potassium reaction, and im-permeability, the use of concrete with fly ash is preferred.

A concrete mixture can also be made using crushed rock flour in place of natural sand. Concrete can be made lighter without sacrificing strength by using crushed ceramic aggregate. Based on grain size information, stone dust can be utilized as a replacement for sand in concrete. Rock flour can substitute sand up to 40% without compromising strength and workability. Rock flour can completely replace the sand in this process.

Advantages and disadvantages of various materials replacing sand

- Quarry dust has used fractional replacement of natural river sand in concrete.
- It has been used for 40% replacement of sand by mine dust gives supreme results in strength compared to normal concrete
- Quarry dust in concrete not only improves the value of the material but also safeguards the natural river sand for approaching generations.
- At present time quarry dust is used for agricultural as well as landscaping purposes.
- Crushed brick aggregates as substitute aggregates include decreasing mortar density, and minimizing natural aggregate use, and is deemed an environmentally friendly approach.
- Bottom fly ash reduces the dead load on structures due to its lightweight.
- It is quite cost-effective.
- The use of fly ash is environmentally friendly because waste products from industries are efficiently used to create high-quality construction materials.
- Fly ash contains such tiny particles, the concrete becomes extremely thick and loses some of its permeability. It might offer extra strength to the construction.
- silica fumes, improve the compressive strength of the mortar and enhance the mechanical and durability properties of concrete.
- Copper slag is frequently used in the manufacturing of abrasive tools, roofing granules, cutting tools, tiles, glass, road foundation construction, railway ballast, asphalt pavements, cement, and concrete.
- Copper slag, used as a fine aggregate in the concrete mix, promotes excellent interlocking, improving the volumetric and structural quality of various mixtures.
- GGBS has a high concrete mixture content and is rich in silicates of calcium, a substance that strengthens the concrete and enhances its toughness, durability, and aesthetic appeal.

Disadvantages

- Using quarry dust Shrinkage is more in when compared to that of the natural river sand.
- Without using any Admixture it gives lower strength as compared to sand.
- Its is not angular in shape that way it reduces the strength of the concrete.
- Crush bricks have low strength, high porosity, high water absorption, high powder content, and poor property stability.
- Fly-ash, Slower strength gain, Seasonal limitation, Increased need for air-entraining admixtures, increase in salt scaling produced by higher proportions of fly ash.
- In case the external temperature is high, Silica fume will lead to early dry shrinkage. Hence, it is more prone to cracks which may ultimately affect the overall strength.

- copper slag can also contain traces of toxic metals such as arsenic, beryllium, and cadmium. These metals not only have a negative effect on human health but can also contribute to the pollution of air and water.
- Ground Granulated Blast Furnace Slag (GGBS) has Slow and small hydration heat, not suitable in precast factories or during winter concreting.

PARTIALLY REPLACEMENT OF CEMENT

I. Ground granulated blast furnace slag:-

This paper Examined the influence of floor slags on the environment (GGBFS) to discover flow relationships. [11] They analyzed mechanical and electrical qualities such as strength properties, water permeability, and power at 50 and 100 volts. It came to curing, the control group's compressive strength was in the range of 29.1-1.7 mpa after 28 days, but PZT's impact strength was in the range of 26.8-30.0 mpa. The control group performed better in the electricity property test under 50 V, while PZT performed worse. The compressive strength and electrical resistance tests revealed that as the GGBFS system will typically, the compressive strength or contact conductivity dropped.

Fig :-07 GGBFS

II. Fly ash :-

Fly ash is often smaller and more crystalline than limestone and Portland cement. Bottom ash is made up of silt-sized, often microspheres with sizes around 10 to 100 microns. Concrete mixture is more fluid and workable due to such tiny glass particles. One of the key characteristics influencing fly ash's pozzolanic reactivity is its fineness.

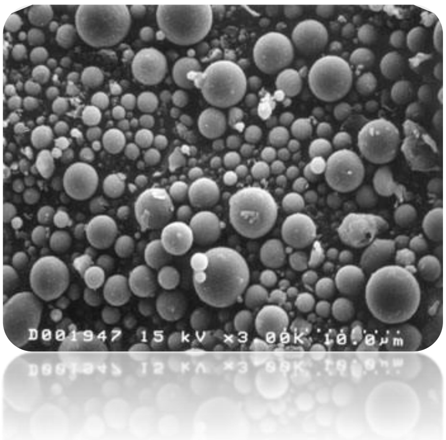


Fig :-08 Fly ash particles at 2,000x magnification.

In this paper they use fly ash (bottom ash) concrete as a partial substitute for cement is becoming more and more significant. [12] Technological developments in thermal energy plant processes and fly ash collecting technologies have enhanced the quality of bottom ash. Fly ash is used in place of some of the cement to explore the usage of fly ash in concrete. In this experiment, different levels of fly ash (0%, 25%, 50%, 75%) were added to concrete. Ductility, setting time, flexural modulus, and moisture content of bottom ash were all examined for their impacts. To find out how the characteristics of concrete would change if bottom ash were used in place of some of the cement, tests on different concrete mixtures were conducted.

Approximately twenty million metric tonnes (21 million tones), or 32% of the entire production of 60 million metric tonnes (66 million t) of bottom ash generated in 2001, was utilized.

The applications of bottom ash, which are primarily found in the transportation sector, are subdivided in the table below.

Table:- 01 Fly-ash uses

Fly ash uses			
	Million Metric Tons	Million Short Tons	Percent
Cement/Concrete	12.16	13.40	60.9
Flowable Fill	0.73	0.80	3.7
Structural Fills	2.91	3.21	14.6
Road Base/Sub-base	0.93	1.02	4.7
Soil Modification	0.67	0.74	3.4
Mineral Filler	0.10	0.11	0.5
Mining Applications	0.74	0.82	3.7
Waste Stabilization /Solidification	1.31	1.44	6.3
Agriculture	0.02	0.02	0.1
Miscellaneous/Other	0.41	0.45	2.1
Totals	**19.98**	**22.00**	**100**

III. Nylon-fiber

In this paper, they use nylon fiber to replace a partial amount of cement. [13] the characteristics of 80-mm-thick paver blocks made of M-40-grade concrete designed for moderate areas are evaluated. In this, they use nylon fiber in the concrete of paver blocks up to 0.5% of the weight of cement at intervals of 0.1%. After determining the optimal percentage for nylon fiber, rice husk ash (RHA) has substituted for cement in the concrete of paver blocks in varying percentages of 10%, 20%, and 30%, and the workability of the concrete has been evaluated.

Fig :-09 Nylon-fiber

iv. White paper slug

In this paper, they use, a wastepaper slug for the partial replacement of cement. [14] Paper is the main constituent material. The E-type waste white office papers were used for making slugs. For 25 mpa of concrete, four concrete mixtures containing 0%, 5%, 10%, and 15% recyclable pulp ash in place of OPC and PPC were prepared.

Based on the study's findings, the greatest compressive strengths at 3, 7, and 28 days were 24.36, 28.35, and 36.83 mpa, respectively. For OPC, all percentage substitutions showed strength property reductions compared to the control mix, while for PPC, all percentage replacements showed increases.

With more wastepaper pulp ash added to concrete than to control concrete, the concrete's ability to absorb moisture was improved. Comparing mixed concrete made of OPC-WPPA and PPC-WPPA to control concrete, it is obvious that the latter has the lowest resistance to a 2% solution of sulfuric acid.

Fig :-10 Waste white paper

v. Rice husk :-

In this paper, they use rice husk to partially replace cement. [15] Due to the pozzolanic tendency of cement, several industrial wastes, and agricultural by-products, such as fly ash, rice husk ash, silica fume, and slag, can be used in place of cement, saving enormous tracts of land that are needed for disposal. Rice husk ash was employed as a cement additive in concrete, and its qualities were examined.

Additionally, an effort was made to investigate the concrete's strength and workability criteria. The Indian Standard (IS) approach is used to create mix designs for regular concrete, and using this method as a guide, mix designs have been created to substitute rice husk ash. In relation to the replacement approach, four distinct replacement levels—5%, 10%, 15%, and 20%—are chosen and investigated.

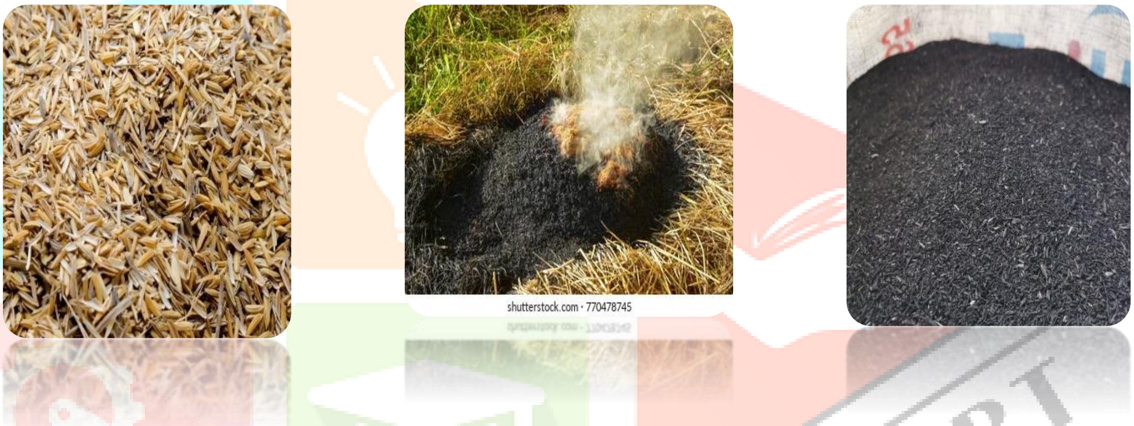


Fig :- 11 The pure form of rice husk, burning of rice husk, and burn rice-husk

vi. Coal Fly-ash

In this research paper, Cement may be replaced with coal fly ash in the concrete industry. [16] Coal Fly ash should be noted, which ranges in mass from 15% to 25%, and has been employed as a cementitious ingredient in concrete. The concrete's compressive strength was tested by substituting various amounts of cement with fly ash. However, the precise quantity to be utilized largely depends on the characteristics of fly ash, the application techniques, the geographic location, and the meteorological conditions of the region in question. Many studies have been conducted on the use of coal fly ash as an addition to cement, an admixture in concrete, and a cement replacement material.

Advantages and disadvantages for various materials replacing of partial amount of cement

- Ground granulated blast furnace slag reduces the risk of thermal cracking in large pouring, and reduces shrinkage cracks in the cement. But reducing workability of concrete.
- It possesses good pumpable and compaction characteristics.
- it contributes to producing sustainable concrete.
- Fly ash use in concrete improves the workability of plastic concrete, compressive strength, and durability of hardened concrete.
- Nylon fiber added to concrete improves tensile strength. but decreases workability.
- It imparts impact resistance and flexural toughness and sustains and increases the load-carrying capacity of concrete.
- White paper slug Improved workability. Easier playability and finish ability, durability, and flexural strengths.
- Agricultural waste, such as rice husk ash (RHA), can be used instead of cement in the concrete making, producing efficient concrete with improved concrete properties like impermeability, workability, strength, and corrosion of steel reinforcement. But with more quantity use of rising husk ash, concrete progressively becomes unworkable.

III. OBJECTIVE

The main object of this paper is to discuss the various changes in the cement sand proportion.
like.

- How can we partially replace the cement from fly ash and sand with a different material?
- How does cement give more strength and how much we can replace this?
- What is the role of fine aggregate in the concrete mixture?
- How fine aggregate is responsible for high strength?
- How many percent of scholars replace natural cement?
- What type of material do they mix to increase the strength of the concrete?

IV. CONCLUSION

- Examine research paper suggests that the compressive strength of concrete mixes decreases with the increased presence of Fly Ash. It should be kept in mind that the optimum limit of mixing Fly Ash is 35 % and more than that may not be safe for different concrete mixes.

- Generally, with the increase of fly ash, there is a steep increase in strength from 7 to 28 days which is indicative that the early strength of concrete is reduced with an increase in the proportion of fly ash.

- Depending upon the percentage of Fly Ash as well as the time of curing mixes of higher strength can be more economical than that a mix of lower strength.
- From the following studies and other paper studies we found that the results of quarry dust as a fine aggregate have relatively low strength (60 to 50) compared to the river sand used in the study.

- The concrete mix of dust as partially replaced with sand, results in a reduction in the compressive strength.

- In the presence of silica fume or fly ash, quarry dust can be suitable for partial replacement material to sand to produce concretes with fair ranges of compressive strength.

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