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A COMPARATIVE STUDY ON THE EFFECTS OF PARTIAL REPLACEMENT OF FINE AGGREGATE WITH MARBLE DUST IN CONCRETE: A REVIEW

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Abstract - *Concrete is one of the most widely used construction materials globally, and its composition significantly impacts its properties and performance. The quest for sustainable construction practices has led researchers to explore alternative materials to enhance concrete's mechanical properties while reducing environmental impact. Marble dust, a byproduct of marble processing, has emerged as a potential candidate for partial replacement of fine aggregate in concrete mixtures. This review paper presents a comprehensive comparative study of the effects of incorporating marble dust in concrete mixes. Various aspects such as workability, compressive strength, tensile strength, durability, and environmental implications are critically analyzed and compared with traditional concrete mixtures. The review highlights the influence of different factors such as marble dust particle size, dosage, and curing conditions on the performance of marble dust concrete. Furthermore, challenges and opportunities associated with the utilization of marble dust in concrete production are discussed, providing insights for future research directions. Through a systematic evaluation of existing literature, this review aims to offer valuable insights into the potential of marble dust as a sustainable alternative in concrete production and pave the way for informed decision-making in the construction industry.*

Key Words: Concrete, marble dust, fine aggregate replacement, sustainable construction, mechanical properties, compressive strength, tensile strength.

1.CONCRETE AND ITS COMPONENTS

Concrete is a widely used construction material composed primarily of cement, aggregate (such as gravel and sand), and water. It's a versatile material that can be formed into various shapes and sizes, making it suitable for a wide range of construction applications, from buildings and roads to bridges and dams. Here are the main components of concrete:

Cement: Cement is the binding agent in concrete. It's a fine powder made from limestone, clay, and other minerals that are heated in a kiln and then ground to a fine powder. The most common type of cement used in concrete is Portland cement, which accounts for the majority of cement production worldwide.

Aggregate: Aggregates are granular materials such as sand, gravel, crushed stone, or recycled concrete that make up the bulk of concrete. They provide strength and durability to the concrete mixture. Aggregates are divided into two categories: coarse aggregates (such as gravel or crushed stone) and fine aggregates (such as sand). The proportions of coarse and fine aggregates used in concrete mixtures vary depending on the desired strength and workability of the concrete.

Water: Water is essential for the chemical reaction that binds the cement and aggregates together to form concrete. The amount of water used in a concrete mixture affects its workability, strength, and durability. Too much water can weaken the concrete, while too little water can make it difficult to work with and result in a less durable final product.

Admixtures: Admixtures are additional materials added to concrete mixtures to modify its properties or enhance its performance. They can be used to improve workability, increase strength, reduce water content, or enhance durability. Common types of admixtures include air-entraining agents, water reducers, accelerators, retarders, and plasticizers.

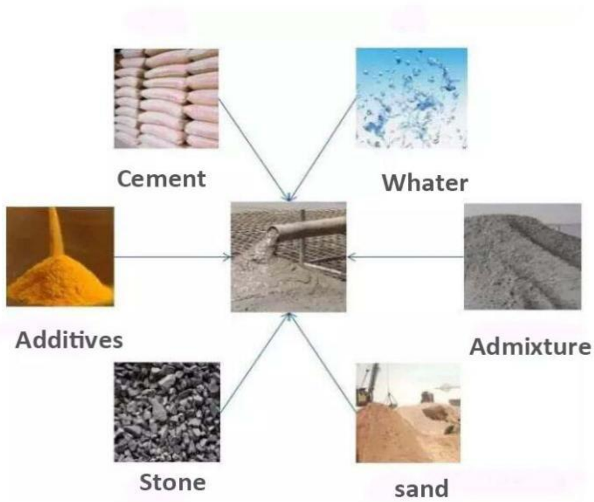

Figure-01: Component of concrete

2.IMPORTANCE OF FINE AGGREGATE IN CONCRETE

Fine aggregate is an indispensable component in concrete, playing a multifaceted role in determining its properties and performance. Primarily, it enhances the workability of concrete mixtures by filling the voids between coarse aggregates and facilitating smooth placement and finishing. Moreover, fine aggregate significantly contributes to the strength and durability of concrete by promoting proper particle packing and enhancing the bonding with cementitious materials during hydration. This not only ensures structural integrity but also optimizes the use of cement, thereby offering economic benefits. Additionally, fine aggregate aids in controlling volume changes, minimizing cracking, and improving dimensional stability. Its texture influences surface finish, making it crucial for aesthetic applications. Furthermore, fine aggregate helps mitigate issues like bleeding and segregation, ensuring uniformity in the mixture. Lastly, in scenarios requiring pumping, the quality and gradation of fine aggregate are pivotal for maintaining flow characteristics and preventing blockages. In essence, the importance of fine aggregate in concrete lies in its ability to enhance workability, strength, durability, economy, surface finish, volume stability, and pumpability, making it an indispensable constituent of concrete mixtures.

Figure-02: Fine Aggregate

3.MARBLE DUST

Marble dust, a finely ground powder originating from the grinding of marble, finds versatile applications across diverse fields. Primarily embraced by artists and sculptors, it serves as a fundamental material for crafting sculptures and artworks when combined with binding agents like resin or plaster. Additionally, in construction, it bolsters the properties of concrete and mortar mixes, enhancing their strength, durability, and workability. Marble dust also plays a significant role in the production of marble-based flooring tiles and countertops, augmenting both their aesthetic appeal and performance. Moreover, it features in cosmetics and personal care products, contributing to exfoliating scrubs and masks owing to its gentle yet effective removal of dead skin cells. In horticulture, gardeners integrate marble dust into potting mixes or soil amendments to improve drainage and aeration, along with soil pH adjustments. Furthermore, it is instrumental in the restoration and polishing of marble surfaces, providing a lustrous finish when mixed with water or polishing compounds. While boasting diverse applications, prudent handling of marble dust is imperative due to potential respiratory hazards associated with its dry form. Thus, adherence to safety protocols is paramount to mitigate health risks.

Figure-03: Marble Dust.

3.1.CHARACTERISTIC OF MARBLE DUST

Marble dust possesses several characteristics that make it a valuable material for various applications:

Fine Particle Size: Marble dust is typically ground to a very fine particle size, which gives it a smooth texture and allows it to be easily mixed with other materials such as resins, plasters, or concrete.

White Color: Depending on the source of the marble, marble dust is often white or off-white in color. This coloration is desirable for many applications where a bright, clean appearance is preferred.

Chemical Inertness: Marble dust is chemically inert, meaning it does not react with most substances. This property makes it suitable for use in a wide range of applications without causing unwanted chemical reactions.

Compressive Strength: When incorporated into concrete or mortar mixes, marble dust can enhance the compressive strength and durability of the resulting material. This makes it valuable in construction applications where strong, long-lasting structures are required.

Aesthetic Appeal: In art and sculpture, marble dust is valued for its ability to mimic the appearance and texture of marble when mixed with binding agents. It can create a visually striking finish that resembles real marble at a fraction of the cost.

Absorbent Properties: Marble dust has absorbent properties, which can be beneficial in applications such as cosmetics and horticulture. It can help absorb excess moisture or oils, making it useful in formulations for skincare products or as a soil amendment in gardening.

4.REPLACEMENT OF MARBLE DUST AS FINE AGGREGATE

The replacement of marble dust as a fine aggregate in concrete or other applications can have several implications, both positive and negative. Here are some points to consider:

4.1.Positive Aspects

- **Resource Conservation:** Utilizing marble dust as a substitute for traditional fine aggregate can help in conserving natural resources by reducing the demand for sand, which is often dredged from rivers and beaches.
- **Waste Reduction:** Marble dust is often a byproduct of marble processing industries. By using it as a replacement for fine aggregate, it provides a sustainable solution for disposing of this waste material.
- **Improved Aesthetics:** Depending on the source and quality of the marble dust, it may offer aesthetic benefits by imparting a unique appearance to concrete or other materials, such as a white or off-white coloration that resembles natural marble.
- **Enhanced Properties:** Marble dust can contribute to improved properties of concrete, such as increased compressive strength, reduced permeability, and enhanced durability, when used in the appropriate proportions.

4.2.Negative Aspects

- **Workability Issues:** Marble dust may affect the workability of concrete mixes due to its finer particle size and different particle shape compared to traditional fine aggregate like sand. Adjustments to the mix design may be necessary to maintain desired workability.
- **Potential Alkali-Silica Reaction (ASR):** There is a risk of alkali-silica reaction when using marble dust, particularly if it contains reactive silica components. This reaction can lead to expansion and cracking of concrete over time, compromising its structural integrity.
- **Cost Considerations:** While marble dust may be readily available as a waste product from marble processing, transportation and processing costs, as well as any additional processing required for its use as a fine aggregate replacement, could affect its overall cost-effectiveness compared to traditional materials.
- **Quality Control:** Ensuring the consistent quality of marble dust can be challenging, as it may vary in composition and properties depending on factors such as the source of the marble and the processing methods used. Quality control measures may be necessary to maintain desired performance.

5.STRENGTH IMPROVEMENT OF THE CONCRETE BY USING DIFFERENT FINE AGGREGATE.

Improving the strength of concrete can be achieved through various means, one of which is by utilizing different types of fine aggregates. Fine aggregates typically constitute a significant portion of concrete mixtures and play a crucial role in determining the properties of the concrete. Here are some ways in which the strength of concrete can be enhanced by using different fine aggregates:

1. **Particle Shape and Texture:** The shape and texture of fine aggregates can significantly influence the strength of concrete. Using fine aggregates with angular or rough surface texture can improve interlocking between particles, leading to increased strength compared to rounded or smooth aggregates.
2. **Grading of Aggregates:** Properly graded fine aggregates ensure better packing density within the concrete mixture, resulting in improved strength and reduced voids. Fine aggregates with a continuous grading curve can enhance the overall performance of concrete.
3. **Size and Fineness Modulus:** Fine aggregates with a suitable size distribution and fineness modulus can enhance the workability and strength of concrete. A balanced combination of coarse and fine particles can optimize packing density and reduce the amount of cement paste required, thereby improving strength.
4. **Mineralogy and Composition:** Different types of fine aggregates, such as sand, crushed stone dust, quarry dust, manufactured sand, etc., possess varying mineralogical compositions. Some aggregates may contain minerals that contribute to pozzolanic reactions, resulting in improved strength and durability of concrete.
5. **Surface Characteristics:** Surface characteristics such as porosity, absorption, and surface roughness of fine aggregates can influence the bond between aggregates and cement paste. Fine aggregates with low porosity and absorption rates tend to produce concrete with higher strength and durability.

6. **Chemical Admixtures:** Incorporating chemical admixtures such as silica fume, fly ash, metakaolin, or microsilica in concrete mixtures can enhance the strength by filling voids, improving particle packing, and promoting pozzolanic reactions with calcium hydroxide.

6.LITERATURE SURVEY

In this,we will study about the previous research work based on the replacement of the fine aggregate from the concrete by using the different material. The summary of the previous research are given below in the details.

Fikri & Ninda: Partial replacement of fine aggregate with marble dust in concrete showed an optimal 6.62% replacement by weight of cement, increasing compressive strength by 11.77% in the experimental study. Marble dust can be used as a filler in concrete to reduce cement content. The optimum usage of marble dust is 6.62% by weight of cement, resulting in a 11.77% increase in compressive strength of concrete. Marble dust was used as an alternative material in concrete. The addition of marble dust increased the compressive strength of concrete.

Yeng et.al: Optimum percentage of 10% FMK and 10% CBA had highest compressive strength. 10% to 50% CBA replacement is suitable with 10% FMK substitution. Investigated combination of fine-metakaolin and coal bottom ash in seawater-concrete. Found 10% FMK and 10% CBA had highest compressive strength.

Shahid et.al: RHA and RWG can be used as partial replacements in concrete 10% replacement of RHA and RWG is recommended. RWG can replace natural sand in concrete production RHA can replace cement in concrete production.

Bishen & Madan: Partial replacement of cement with marble dust in concrete enhances compressive strength. Marble dust improves concrete quality by densifying the matrix, as shown through Ultrasonic Pulse Velocity testing. Optimum value of marble dust as substitute for cement is around 10%. Good quality concrete can be developed with up to 10% marble dust. Marble dust is investigated as a partial replacement for cement in concrete.Compressive strength and ultrasonic pulse velocity tests are conducted to assess the quality of the concrete.

Zuzanna et.al: In this article , the effect of replacing cement with waste granite powder on the properties of fresh and hardened mortars intended for masonry applications was studied. And the results showed that the partial replacement of cement with the granite powder significantly increased the water sorption coefficient and the consistency of the fresh mortar, and its density and water absorption also increased when compared to the reference series. Granite powder can partially replace cement in masonry mortars. Properties of mortars with granite powder are comparable to reference series.

Zalipah et.al: In this paper , the effect of a lower sand replacement content (5 – 25%) in glass waste (smaller than 5 mm) on both the mechanical and durability properties of concrete was investigated. Lower replacement percentage of glass waste enhances concrete properties. Glass waste can act as a sustainable and alternative material in the future.

Basaran et.al: Partial replacement of fine aggregate with marble dust in concrete can significantly impact compressive strength, with up to 50% replacement showing notable changes, as indicated by multivariate regression analyses. In this article , the results of axial compression tests on a total of 429 concrete mixtures with marble aggregates were compiled by paying special attention to reporting all test variables (form and content of marble wastes, water-cement ratio, cement content, proportion of coarse and fine aggregates in all aggregates) affecting the concrete strength. Replacing fine aggregates with marble powder up to 15% improves compressive strength. Replacing both fine and coarse aggregates with marble aggregates may have adverse effects on compressive strength.

Roshan et.al: In this article , the authors used different dosages of marble waste aggregates (MWA) and stone dust (SD) as a replacement for coarse and fine aggregate, respectively, to evaluate the physical properties of concrete. Partial substitution of MWA and SD in concrete is feasible. Optimal mixture: 15% MWA and 50% SD for higher strength.

Haitham et.al: In this paper , the effect of the partial replacement of ordinary Portland cement with CKD on the engineering properties of pozzolanic concrete for use in block manufacturing was investigated, and the results showed that increasing CKD content lowered the voids and increased the water absorption. Increasing CKD content lowers voids and increases water absorption. 15% CKD sample has highest compressive strength.

Zhao et.al: In this article , the authors proposed a methodology for quantitatively assessing the life-cycle economic and environmental impacts when rock dust is used in PCC pavement roadway construction, which can achieve substantial benefits in saving nature resources and reducing energy consumption as well as greenhouse gas emissions. Using rock dust in concrete pavements provides cost savings and environmental benefits. The best sustainable option is to replace 20% fine aggregate and 10% cement with rock dust.

Kiran et.al: In this article , the authors explored the use of waste plastic as a fine aggregate replacement in medium-strength reinforced concrete pavements, for improving plastic aggregate performance and the intrinsic reasoning for observed strength performance. 5% replacement of fine aggregates with plastic waste is feasible. 10% plastic replacement may be feasible in non-primary structures.

Farah et.al: In this article , the influence of spent garnet as a fine aggregate substitute on the fresh, mechanical, and durability properties of palm oil clinker concrete was determined, including workability, compressive strength, flexural strength, splitting tensile strength, modulus of elasticity, water absorption, and acid resistance of the water cured concrete. Workability of concrete increased with the increase of spent garnet content. Durability properties such as water absorption and acid resistance were enhanced.

Christopher et.al: In this paper , a study was conducted to evaluate the durability and investigate the microstructure of concrete with fine aggregate partially replaced by pulverized termite mound (PTM). PTM improves durability of concrete up to 70% replacement. Concrete with PTM has smaller pores compared to control.

Thamer et.al: In this paper , the measured mechanical characteristics of concrete were studied in five mixes, both with and without internal curing, and the results showed that the ceramic and Attapulgite internal curing purposes were highly effective, especially with a 20% replacement. Ceramic and Attapulgite internal curing materials enhance concrete characteristics. 20% replacement rate shows highest compressive resistance improvement.

Aliyu et.al: In this paper, the effect of partially replacing cement with quarry dust in cement-sand mortar was investigated, and the results showed that the partial replacement shows an improvement of compressive strength at 5% quarry dust content after which there is a decrease with increase in quarry dust contents at all the ages. Quarry dust can replace cement up to 5%. Above 5%, it can replace fine aggregate in low-strength mortar.

Jahanzaid et.al: In this paper, an endeavor has been made to think about the regular concrete and lightweight total substantial utilizing blend M25, which is made by Partial Replacement of Coarse Aggregate with various proportions of Pumice going from half, 60%, and 70%. Best strength with 60% pumice aggregate replacement. Lightweight concrete suitable for non-structural partitions.

Chamini et.al: In this paper, the feasibility of using fly ash as a partial fine aggregate replacing material in concrete and its effects on the compressive strength and some significant durability properties when cured under different curing temperatures. Fly ash as a partial fine aggregate replacement increases compressive strength in concrete. Higher fine aggregate replacement percentage leads to higher strength gain.

Bilawal et.al: The study focuses on the combined effect of marble powder and ceramic tile waste as partial replacements in concrete, impacting workability and compressive strength negatively with increasing replacement ratios. In this article, the combined effect of waste marble powder (M.P) and Ceramic tile waste (CTW) as partial replacement of Cement (10%) and Coarse Aggregates (10,20,30% respectively) is observed and analyzed. Compressive strength of concrete with replacement is approximately same as that of Conventional Concrete at (10%+10%). Workability and Compressive Strength of Concrete decrease with increasing ratio of replacement.

Priya et.al: The study focuses on partial replacement of cement with marble dust and glass powder in concrete, aiming to reduce costs, control emissions, and promote eco-friendly construction practices. The use of waste marble powder as a partial replacement of cement can reduce the cost of cement and also, control the emission of harmful dust into environment and proving to be eco-friendly to the environment as mentioned in this paper. Slump of fresh concrete increased at 30% replacement (10% marble dust powder, 20% glass powder). Strength loss in compressive, flexural, and split tensile strength increased after 30% replacement.

Begashaw & Bahiru: Partial replacement of sand with marble waste in concrete enhances compressive strength but reduces workability. Optimum levels are 22.5% marble waste and 44.5% scoria, saving costs up to 4.5%. In this article, the chemical, physical, mechanical, and fresh property of concrete containing marble waste and scoria was investigated and it was shown that the workability and compressive strength decrease with an increase in the content of marble waste. Concrete containing marble waste and scoria shows better compressive strength. Optimum replacement level is 22.5% marble waste and 44.5% scoria.

Habib & Maan: Partial replacement of fine aggregate with marble dust in concrete positively impacts strength and microstructure properties, enhancing flowability and cohesion, as shown in recent research trends. In this paper, the authors summarize recent investigations on the properties of concrete incorporating marble waste as cement replacement materials, highlight the potential gaps in the literature, and propose a prediction model for estimating the compressive and flexural strengths of concrete with marble dust using regression analysis. Marble dust can positively impact the strength and microstructure properties of concrete. Marble dust can be used as a filler to improve the flowability of cement-based material.

Pradeep & Vias: The study compared the effects of replacing fine aggregate with marble dust in concrete, showing increased compressive and flexural strength initially, peaking at 20% marble powder replacement. In this paper, a design mix of concrete was designed by partially replacing cement with bagasse ash, fine aggregate with marble powder and coarse aggregate with recycled concrete aggregate at varying proportions. Compressive strength peaks with 20% SBA, 20% Marble Powder, 25% RCA. Split tensile strength peaks with 20% SBA, 40% Marble Powder, 25% RCA.

7.CONCLUSION

In conclusion, this comparative study on the effects of partial replacement of fine aggregate with marble dust in concrete provides valuable insights into the potential benefits and challenges of utilizing marble dust as a sustainable alternative in construction materials. Through a thorough examination of various parameters including compressive strength, workability, durability, and environmental impact, it becomes evident that the incorporation of marble dust can significantly influence the properties of concrete. The findings suggest that while marble dust can enhance certain properties such as workability and reduce the demand for natural resources, its impact on compressive strength and durability may vary depending on factors such as particle size, percentage replacement, and curing conditions. Moreover, considerations regarding the potential alkali-silica reaction and the long-term performance of concrete structures are essential for ensuring the sustainability and reliability of this approach. This review underscores the importance of further research and experimentation to optimize the use of marble dust in concrete production. Collaborative efforts among researchers, engineers, and industry stakeholders are crucial for developing standardized guidelines and best practices to harness the full potential of marble dust as a viable solution for sustainable construction. By addressing these challenges and leveraging the benefits of marble dust, the construction industry can move towards more eco-friendly practices while maintaining the desired performance and longevity of concrete structures.

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