International Journal of Advance Industrial Engineering
E-ISSN 2320 –5539
Available at http://inpressco.com/category/ijaie/

Review Article

A comprehensive review on the use of marble waste in concrete

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Received 23 Aug 2022, Accepted 02 Sept 2022, Available online12 Sept 2022, **Vol.10, No.3 (Sept 2022)**

Abstract

Many researchers in the construction sector have recently taken up the issue of replacing some of the cement and/or natural aggregates used in the daily manufacturing of cement-based materials with non-biodegradable trash. Due to its availability and the fact that it is produced in such large quantities and poses major environmental issues, numerous attempts have been made to understand the impact of using marble dust in concrete. In the majority of earlier research, marble dust was used in place of cement, fine aggregate or coarse aggregate. In the studies reviewed here, dimensional stone waste from the extraction and processing of marble is examined as a component of concrete. The effects of substituting marble debris for normal components on the mechanical, fresh, and durability qualities of concrete were investigated. It can be said that Instead of just replacing conventional Portland cement, it is more advantageous to blend marble debris with fly ash before using it as a binder. On the other side, marble waste can be used to substitute fine and coarse aggregate in greater quantities while still producing acceptable results. The performance depends on the fine aggregate that the waste is replacing as well as the particle size distribution of the coarse aggregate's geological origin. The findings showed that the coarse/fine aggregate, cement, and admixture materials could be adequately replaced in concrete by waste marble when used at specific ratios, and the resulting concrete had a higher strength.

Keywords: *Cement, Natural aggregates, Coarse/fine aggregate, Marble waste*

1. Introduction

The recent rapid depletion of natural resources, particularly energy and raw materials, was caused by rising material demand brought on by industrial growth. Additionally, as production rises, a sizable amount of garbage is produced, which has a detrimental effect on the environment. To reduce the negative effects, a number of nations and international organizations examined waste recycling. More research on waste marble is required if we are to produce eco-efficient, eco-friendly, and usable material. There has been a rise in the usage of marble in construction, particularly in recent years. As a result, the amount of trash generated in the marble industries expanded beyond what could be stored. Economic benefit and the prevention of environmental degradation are both possible by employing these by-products that cannot be kept in other industries [1].

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DOI: https://doi.org/10.14741/ijaie/v.10.3.2

Waste has a noticeable detrimental impact on the environment, including the air, water, flora, animals, human health, and living situations. Global trash production is anticipated to increase from 12 billion tons in 2002—11 billion of which were industrial waste to 25 billion tons in 2025 [2-3].

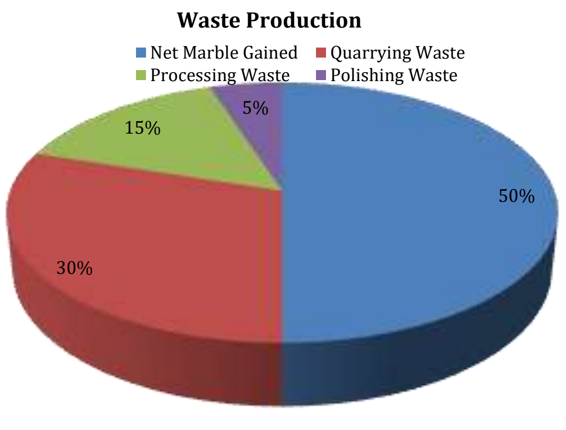

Fig. 1 Proportion of waste produced in the marble industry

In the absence of adequate action, it is obvious that the growth will represent a serious threat to environmental health. 20–30% of a marble block is reduced to waste marble powder during the cutting process. According to Figure 1, marble powder is a waste product that is produced in large quantities throughout the world.

Studies on waste management are growing steadily around the world. Waste marble is a significant contributor to the contamination of the environment because the marble industry is a growing one. It is believed that using raw materials that can't be stored in industries offers significant economic and environmental advantages. According to Uysal and Ylmaz [4], the 28-day cost analysis of conventional concrete came out to be US$0.58/MPa/m^3, whereas the cost analyses for samples containing 10%, 20%, and 30% marble powder, respectively, came out to be US$0.52/MPa/m^3, US$0.48/MPa/m^3, and US$0.47/MPa/m^3. The findings showed that waste marble-infused concrete is roughly 15% less expensive than traditional concrete. In order to stop groundwater contamination and decreased soil productivity brought on by marble slag waste in Sicily, presented alternate options. They used simultaneous thermal analyses and X-ray refraction to study the marble slag. According to the study, marble slag's high chemical concentration can have a harmful impact on the environment. They came to the conclusion that recycling garbage is vital. Arel reviewed the literature and looked at research that looked at using scrap marble in place of cement and aggregate while making concrete. Concrete's compressive strength was enhanced when leftover marble was recycled instead of using aggregate. The measurements showed that the workability was improved by using scrap marble rather than coarse material [5].

Unacceptable amounts of garbage are produced by construction projects that are expanding quickly. Construction waste is the residue left over from building renovation, demolition, and road construction projects [6]. Despite numerous marble mines around the world, natural stones made from construction waste, particularly marble, are non-renewable [7]. Marble has been widely used as a building material throughout history. Crystalline metamorphic rocks like marble can be sculpted for use as floors, monuments, and decorative elements [8]. The amount of marble trash created rises as a result of the building industry's increased demand for marble products [9]. The fabrication of large panels and rock blocks are the two most typical uses for marble dust [10]. When cutting and shaping marble applications, a sizable amount of waste is produced as a result of the wide application, generating dust particles [11-12]. About 25% of the marble has been dusted [9]. But as indicated in Table 1, it was found that the volume of waste marble dust created varied proportionally, ranging from 20 to 80%.

Table 1 Percentage generation of marble dust waste

Source	Marble dust (%)
Alyamaç and Ince (2009) [13]	20-30
El Haggar (2010) [14]	20-25
Marras et al. (2010) [15]	20-30
Mehta and Mehta (2015) [16]	30-40
Choksi et al. (2018) [17]	40
Li et al. (2018) [18]	80
Manjuladevi and Chore (2021) [19]	40

Additionally, these produced waste materials contaminate natural resources and have a negative impact on the ecosystem [20]. Additionally, Oza noted that marble dust contains harmful compounds for employees' health. Marble extraction raises environmental concerns, yet it is acknowledged as a viable raw material for making concrete [21].

2. Methodology

This review was carried out using both recent and older articles of relevant literature that were found to be available on the Google Scholar, ScienceDirect and PubMed, etc. The studies were found by using the following keywords such as marble waste, marble dust and waste marble power in concrete. All of the papers that describe the sustainable use of waste marble powder or aggregate in concrete have been meticulously researched and selected for this review.

3. Marble waste as a partial replacement for cement

The scientific community has made significant efforts over the past few decades to propose creative waste management strategies that can reduce non-biodegradable wastes while also being sustainable. In an effort to develop a greener alternative to traditional construction materials, the construction industry has recently begun to play a more active role in recycling these materials by using them to partially replace the elements in cement-based manufacturing.

According to earlier research [22-23], adding this substance to concrete alters its qualities for freshness, mechanical strength, durability, and porosity. Its primary effect on concrete's ability to support strength-bearing loads is widely thought to be an improvement in strength when a small portion of cement is substituted with marble dust. However, the compressive and tensile strengths of the concrete decrease at large replacement ratios, above 10% to 15%. The high degree of fineness that enables using it as filler in cement-based combinations gives this material relevance in addition to its sustainable advantages as shown in Figure 2. The purpose of this study is to provide a succinct overview on cement-based products integrating marble dust, with a focus on concrete mixtures using marble wastes in place of traditional cement. The study also aims to present estimation models for the compressive and flexural strengths of marble dust concrete using multiple regression analysis and to highlight some findings about the impact of marble dust content and characteristics on changes in concrete strength capacity.

Fig.2 Feasibility of marble powder in concrete as cement

In addition, the qualities of cement composites made by replacing cement with marble debris in increments of 10% from 0% to 40%. These samples required more water than the pure cement pastes when their consistency was evaluated. This could be due to the marble powder's fineness in this study being double that of the cement it was replacing (6700 cm2/g). For a substitute of 10%, both setting times that were observed were much slower than others. These pastes' larger water contents resulted in lower compression resistance even for the smallest substitution value in mortars made with them [24]. Vardhan [25], substituted a sample of dolomitic origin for cement. Due to the marble waste, even the minimum water substitution level of 10% was decreased to the maximum substitution level of 50%. Cement paste flow times were also noticeably shorter, with a notable decrease in time for 10% replacement level alone. Additionally, this waste made OPC take longer to set up initially and ultimately. However, for a substitution range of 10%–20%, the time difference between the start and final setting times decreased. This time gap grew as incorporation continued to rise. Singh et al. also published findings that were comparable [26].

According to Vardhan [25], replacing OPC by 10% would result in cement paste with the same strength as control samples, while Singh authorized the use of 25%. There are two possible causes for this benefit. First off, Singh conclude that the usage of marble waste increased the likelihood of the filler effect since it was finer than the cement it replaced. Second, 8% less water was used in the paste with 25% MS to get the required consistency [27]. Krgz investigated the compressive strengths of the composite cement mortars using calcite marble slurry in place of OPC. To create mortars with a 1:3 proportion and a constant water-to-cement ratio of 0.5, substitutions were made in varying amounts of 6%, 20%, 21%, and 35% [28]. For only 6% replacement, the maximum compressive and flexural strengths were attained. Li replaced cement in the manufacture of mortars with marble waste particles that were smaller than 150 microns. Cement replacement levels of 5%, 10%, 15%, and 20% were used to examine four alternative w/c ratios of 0.4, 0.45, 0.5, and 0.55. These mortars' durability characteristics, including as drying shrinkage, carbonation, and water absorption, were investigated. The carbonation depth of these mortars was dramatically decreased by 30–40% by employing marble debris as a binder and lowering the water content by the use of a superplasticizer. More than 40% less water was absorbed, and drying shrinkage was also decreased. According to ToubalSeghir et al., the fall in compressive strength appears to be more pronounced in cases of air-cured samples [18].

4. Marble waste as a partial replacement for coarse aggregate

The characteristics of marble dust used in concrete and mortar were studied by Corinaldesi [29] in 2010. The findings showed that the strongest material was marble powder, which was utilized to replace sand by 10%. Additionally, it was shown that using marble powder as a filler when children were young had a favorable impact. The availability of waste marble as a natural aggregate in the creation of concrete was examined by Hebhoub [30]. Three sets of concrete mixes were created for experimental investigation by varying the amounts of aggregate gravel and sand. In particular, the combinations contained 25%, 50%, 75%, and 100% marble aggregate. According to the findings, the recycled marble aggregate shown good strength, especially up to 75% replacement. In their study, Soykan and Ozel looked at recycling leftover marble as an aggregate in polymer concrete technology. To create 7-series polymer concrete, different sizes of leftover marble powder were combined with polyester-based resin (PolyPol 314 filler-type polyester). On the samples, physical and mechanical analyses were carried out. Investigated was how marble powder particle size affected the characteristics of polymer concrete. The samples generated using waste marble with a grain size of 0.075-0.150 mm as the phase material had the highest physical and mechanical qualities [31].

Waste marble, waste concrete, crushed sandstone, and fly ash were used by Uygunoglu as replacement aggregates in precast concrete blocks. The results of the investigation indicated that waste marble aggregate was the most appropriate waste due to its favorable effects on mechanical properties including compressive strength and splitting tensile strength [32]. Waste marble powder was used as an ingredient in a study by Omar that looked at the usage of limestone waste to replace fine aggregate used in concrete. Furthermore, concrete mixtures made by substituting limestone waste for sand at rates of 25%, 50%, and 75% each received additions of 5%, 10%, and 15% waste marble powder. Flexural strength, compressive strength, splitting tensile strength, elasticity modulus, and permeability tests were carried out to ascertain the properties of both fresh and hardened concrete. The results indicated that while the unit weight of the concrete remained unchanged, the addition of limestone as a fine aggregate enhanced the slump of fresh concrete. The outcomes showed that adding marble dust to the concrete mix improved the concrete's performance [33]. Waste marble was investigated by Ural as a potential replacement for fine aggregate in concrete. Clayey soil that contains marble powder had specific physical, mechanical, and physicochemical characteristics that were identified.

According to the test results, a certain amount of improvement in the clayey soil behavior was seen. As a result, it was said that leftover marble might be utilized in place of fine aggregate for making concrete. According to the study, 5% of leftover marble is the ideal ratio to utilize as a substitute for fine aggregate [34]. Mishra examined how using marble slag powder in place of natural sand in concrete affected the microstructure and compressive strength of cement mixtures[35]. Another investigation of mechanical properties of fresh and hardened concrete that contained fine aggregate at varied ratios, and the results showed that the strength also rose when the marble powder concentration increased. At rates of 0%, 20%, 50%, and 100%, the waste marble created by the stone quarrying industry replaced the aggregate. Replacements of up to 60% for the current ratios showed improvements in the mechanical properties of the concrete. The findings suggested that using up to 60% of the waste from marble quarries in the making of concrete was appropriate [36]. Alyamac and Tugrul found that employing marble dust and shattered marble fragments instead of aggregates in the manufacturing of concrete can result in concrete that is long-lasting, aesthetically pleasing, and environmentally beneficial [37]. The impact of glass fiber and marble powder on cement mortars heated to high temperatures was studied by Kelestemur. By taking temperature into account, the effects of 0%, 20%, 40%, and 50% (by volume) marble powder replacing sand on the mechanical properties of concrete were examined [38]. Gameiro replaced aggregate at rates of 0%, 20%, 50%, and 100% using trash collected from marble quarries. To distinguish between newly laid and hardened concrete, they performed a number of experiments [39].

However, because these marble-based aggregate mixtures are acid soluble, their residual compressive strength was reduced by 8% when exposed to a sulphuric acid medium. The only notable difference seen after normal fire treatment at 600 °C was a 68% loss in flexural strength compared to control concrete [40]. Finally, Tekin went one step further and used marble waste as a conventional coarse aggregate itself to conduct their investigation on concrete with fly ash. They did this because they had enough knowledge about the performance of marble waste as coarse aggregate [41].

5. Marble waste as a partial replacement for fine aggregate

Cement, coarse aggregate, fine aggregate, and a calculated amount of water are the main ingredients in concrete, a material that is widely used in construction. Typically, natural sand is employed as fine aggregate. The supply of readily available natural sand is insufficient for the needed rapid expansion in structural activity. Additionally, there are instances in which it is necessary to transport premium sand over long distances, and due to the high cost of construction, it is necessary to replace all or a portion of the regular sand in the concrete with an alternative substance without compromising the concrete's superiority. Waste marble dust can be utilized as a fine aggregate substitute for sand. In place of sand as a fine aggregate, leftover marble powder will be used in concrete in this study.

Hebhoub [30], departed from tradition by substituting marble debris, which has a fineness modulus of 3.12, for considerably finer sand (fineness modulus 1.92). At 50% substitution, he was able to perform better in terms of compressive (an improvement of 24%) and tensile strength. These characteristics were less than control concrete at 100% replacement. Marble waste with finenesses of 4372 and 4000 cm2/g was used by Alyamac and Aydin to substitute river sand [20, 42]. They also replaced 90% of the fine aggregate by using a super-plasticiser to make up for the loss in workability. For mixes containing 40–50% marble debris, the mechanical performance and resistance to abrasion were comparable to control concrete. Additionallyallowed within the same range was sorptivity. While the study [42], study demonstrated that 20% of the maximum compressive strength may be achieved, the study claimed that 10% of the maximum gain can be achieved by replacing river sand. The increase in performance was between 7% and 15%. Both of these experiments demonstrate that using marble waste results in an increase in the ratio of tensile to compressive strengths, which denotes a stronger interfacial transition zone. In addition to compressive and splitting tensile strengths, steel concrete bond strength, UPV, and porosity were all investigated by [20]. At 10% substitution, the bond strength reached its maximum, while UPV values remained same, and porosity decreased to its lowest point at 15% substitution. Another investigation [43-44] assessed the use of marble mining waste as fine aggregate for making concrete. As basis lines for comparing marble waste, they used river sand, basalt sand, and granite sand.

In contrast to prior experiments, the grading curve of individual and composite fine aggregates was maintained across all mixtures to eliminate performance variances brought on by changes in particle size distribution. The findings demonstrate that the compressive strength of all concrete mixes decreased, regardless of the type of typical fine aggregate used. When compared to concrete built with river sand, there was a noticeable 20% reduction. The reduction was 4-8% when compared to mixes created with basalt and granite aggregates. Although not as severe as that of compressive strength, the loss in tensile strength and elastic modulus was nevertheless present. This was yet another proof that mixes including marble had stronger ITZs than those made with aggregates from non-carbonate sources. The porosity of the mixture determined the durability characteristics, such as water absorption, carbonation, and chloride ion penetration, whereas the aggregates had little to no impact on the cement's chemistry. The authors attributed the lower drying shrinkage in mixes including marble waste to its better geometric characteristics. The composition of marble waste used by different authors in their work are shown in Table 2. The most current literature on the creation of masonry mortars is that of Khyaliya, Kabeer, and Vyas [54]. In this study, the authors employed marble debris with particles ranging in size from 4.75 mm to 75 to replace fine aggregate to a percentage of 0% to 100%. These mortars had a set flow value of between 105 and 150%. The findings indicated that a 50% substituted mix required the least amount of water. Because of this, the wholly replaced mixture had 125% more strength than the control mixture whereas compressive strength peaked at 50% substitution [54]. Molnar and Manea from Romania investigated the applicability of calcite-based marble slime in plaster (1:5) as a fine aggregate replacement in 2016. Every size fraction was replaced in the following ratios: 25%, 50%, 75%, and 100%.

Table 2 Chemical composition of marble waste used by different authors in their work

Authors	SiO_2	CaO	Al_2O_3	Fe_2O_3	MgO	Na_2O	K_2O	SO_3	Loss of Ignition (%)
Binici et al. (2008) [45]	53.20	9.10	14.10	12.30	8.30	1.20	–	–	0.30
Hebhoub et al. (2011) [30]	0.15	54.86	0.08	0.04	1.03	–	–	–	44.26
Kore et al. (2016) [46]	3.75	33.12	Traces	0.13	17.91	–	–	–	45.07
Aukhor (2009) [15]	1.69	49.07	1.04	0.21	4.47	–	–	–	43.46
Marras et al. (2010) [15]	0.43	54.07	0.14	0.05	0.60	–	–	–	42.62
Ural et al. (2014) [34]	0.615	54.537	–	0.167	0.411	0.695	0.034		43.07
Keleştemur et al. (2014) [47]	0.18	53.24	0.03	0.12	0.10	–	–	–	46.33
Ergün (2011) [48]	0.18	51.70	0.67	0.44	0.40	0.21	–	0.08	46.04
Soliman (2013) [49]	13.8	43.2	2.50	1.90	2.70	0.90	0.60	0.07	43.63
Southararajan and Sivakumar (2013) [50]	–	51.49	0.70	0.33	0.36	0.19	0.25	0.10	44.60
Vaidevi (2013) [51]	28.35	40.45	0.42	9.70	16.25	–	–	–	–
Aliabdo, Abd Elmoaty (2014) [20]	1.12	83.22	0.73	0.05	0.52	1.12	0.09	0.56	2.50
Aruntaş et al. (2010) [52]	0.67	54.43	0.12	0.08	0.59	0.14	–	–	43.40
Kavas (2008) [53]	1.38	53.12	0.37	0.24	0.38	–	0.11	0.24	43.53

According to the authors, the introduction of marble lowered workability in terms of consistency, which was attributed to the binding properties of marble powder. The 25% marble sludge mix's seventh-day compressive strength was 8% higher than the control mortar's strength. However, tests of the specimens' 28th and 60th day strengths revealed a 5% and 40% reduction, respectively, for the identical mix. The requirement to reach a minimum strength of 6 MPa after 28 days of curing was met even with 100% substitution. Last but not least, mix with 25% marble waste had 160% higher strength than control mortar when it came to adhesion to the support layer [55]. For the same property, substitutions of 75% and higher resulted in a reduction in performance.

The use of marble sludge produced by Turkey's marble cutting and sawing industry as a replacement of fine sand (0.25 mm) in the substitution of 20%, 40%, and 50% was explored earlier in 2014 by Keleştemur. For the mix ratio of 1:3 by volume, a consistent w/c ratio of 0.5 was maintained. After 30 cycles of freezing and thawing, compressive and flexure strengths were assessed. According to the author's conclusion, marble served as a filler because it was finer than the sand it replaced, improving the compressive and flexural strengths. The same filler effect did, however, lessen the mortar's resilience to freeze-thaw cycles [38].

According to Vardhan, replacing OPC by 10% would result in cement paste with the same strength as control samples [25], while Singh (a) concluded that the authorized use of 25%. There are two possible causes for this benefit [26]. First off, Singh (b) usage of marble waste increased the likelihood of the filler effect since it was finer than the cement it replaced. Second, 8% less water was used in the paste with 25% MS to get the required consistency [26]. Kirgiz investigated the compressive strengths of the composite cement mortars using calcite marble slurry in place of OPC. To create mortars with a 1:3 proportion and a constant water-to-cement ratio of 0.5, substitutions were made in varying amounts of 6%, 20%, 21%, and 35%. For only 6% replacement, the maximum compressive and flexural strengths were attained [28]. Li replaced cement in the manufacture of mortars with marble waste particles that were smaller than 150 microns. Cement replacement levels of 5%, 10%, 15%, and 20% were used to examine four alternative w/c ratios of 0.4, 0.45, 0.5, and 0.55. These mortars' durability characteristics, including as drying shrinkage, carbonation, and water absorption, were investigated. The carbonation depth of these mortars was dramatically decreased by 30–40% by employing marble debris as a binder and lowering the water content by the use of a superplasticizer. More than 40% less water was absorbed, and drying shrinkage was also decreased [18]. According to Seghir, the fall in compressive strength appears to be more pronounced in cases of air-cured samples [56].

6. Use of marble waste in other areas

In their 2012 study, Quesada investigated the use of different waste products in the construction of light bricks, including sawdust, compost, spent earth oil filtration, and marble. To determine how additive use affected the technological characteristics of bricks, measurements of linear shrinkage, bulk density, suction absorption, water absorption, compressive strength, and SEM results were made. According to the findings, bricks with 5% sawdust, 10% compost, and 15% marble and wasted earth oil filtering had the best mechanical qualities [57]. In 2013, Gandhi conducted an experimental investigation of the Surat region, which has significant soil stabilization. To get around issues caused by the region's soil type, rice husk ash and marble powder were employed as additives. To calculate the soil's rate of swelling and swelling pressure, a regression analysis was done. As a result of the investigation, it was concluded that marble powder and rice husk ash, both of which are inexpensively accessible in the area, may be used to stabilize the soil there. When compared to rice husk ash, marble dust was shown to be more suitable and efficient in the investigation [58].

According to another investigation marble processing industry slag can be used as a filler in natural rubber composites. On the properties of concrete, the impacts of replacing 10, 15, 20, 37, and 75-m selected micro-particles with marble slag were noted. The composites' swellability, mechanical, and curing characteristics were identified. The test findings indicated that increasing the amount of marble powder decreased fracture of the composites while decreasing abrasion loss, compression, stiffness, and modulus [59]. In order to substitute waste marble slag and rice husk in industrial and agricultural waste materials, Ahmed in 2013, looked into the production of hybrid composites in either total or specified ratios. The study looked at the swelling behavior and mechanical properties of hybrid composites made of marble slag, husk ash, and natural rubber. Analyses of the following properties were carried out and the findings were discussed: tensile strength, modulus of elongation at break (at 100% and 300%), tear strength, compression setting, abrasion resistance, hardness, and rebound resilience. The study's objective entailed enhancing the ecosystem and environment by using marble and rubber together [60]. The impact of waste marble on the Tombul hazelnut cultivar and soil characteristics was studied by Tozsin. For a year, field experiments were conducted at Giresun (Turkey). The outcomes showed that the hazelnut production and soil neutralization were both considerably impacted by the use of discarded marble. The pH of the soil rose to 5.88 when the waste marble was added, from 4.71. As a result, the yield of hazelnuts increased from 1120.3 kg/ha to 1605.5 kg/ha. According to the findings, waste marble helped to neutralize the acidic soil and boost the output of hazelnut production [61].

According to Yeşilay, it is fine to incorporate up to 27% of discarded marble dust into the clay mixture for creating ceramic artwork [62]. Buyuksagis looked at the usage of leftover marble dust as a raw material in insulation panel mortars and found that doing so was more practical financially than using dolomite [63]. According to Cinar and Kar, marble dust and polyethylene terephthalate bottles can be used to create composite materials [64].

Conclusion and Future Remarks

The study compared leftover marble to cement, sand, and coarse aggregate in concrete manufacture. Depending on the particle size distribution of marble waste and cement, using 10–15% marble slurry as cement substitute can deliver excellent concrete mix performance, reducing cement use by 10% and CO2 emissions. Studies demonstrate that marble debris coupled with fly ash can be used to replace OPC. Separating marble debris and fly ash reduces performance. The mechanism is unknown. Marble waste does not interact with GGBS when coupled with other pozzolanic materials. Mixes perform better with silica fume. This considerable variance is attributable to silica fume alone, not marble waste and silica fume. Marble waste's particle size distribution determines its substitute range. Using marble debris as a partial replacement for river sand up to 50% retains the mechanical qualities of concrete compared to typical mixtures. Up to 100% marble waste substitution of fine aggregate decreased concrete's mechanical qualities. Marble debris can substitute traditional coarse aggregate depending on its geology. Complete replacement of limestone aggregate is possible, however for other varieties, replacement value relies on dry bulk density.

Researchers have done few investigations on concrete made from marble debris. With this restricted data, concrete with marble aggregate can be utilized in rural and semi-urban locations away from industrial zones. To improve the use of marble waste in concrete, a durability study of concrete made using marble waste as an alternative building material is needed. Carbonates are acid soluble. To measure performance in acidic environments, including acid rains in industrial regions, evaluating marble-incorporated concrete is vital. Most low- to medium-strength concrete investigations used low water-cement ratios. These show that marble aggregates can be used in residential and low-rise construction. In low- and medium-strength concretes, the cement paste and interfacial transition zone dictate strength, not the aggregate. The role of marble aggregate can be appraised further by studying high-strength concrete. This would assist decide if marble aggregates can be utilized when performance is poor.

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