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A State of Art Review: On Usage of Waste Marble Powder In Concrete Production

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ABSTRACT - The waste generated from the industries cause environmental problems. Hence the reuse of this waste material can be emphasized. Marble Dust Powder (MDP) is a developing composite material that will allow the concrete industry to optimise materiel use, generate economic benefits and build structures that will strong, durable and sensitive to environment. MDP is by-product obtained during the quarrying process from the parent marble rock; which contains high calcium oxide content of more than 50%. The potential use of MDP can be an ideal choice for substituting in a cementitious binder as the reactivity efficiency increases due to the presence of lime. In this review paper, replacement of waste marble powder with cement and other coarse aggregates were sum up. As per various studies, it was seen that the waste MDP passing through 90 microns, has used for investigating of hardened concrete properties. Furthermore, the effect of different percentage replacement of MDP on the compressive strength, splitting tensile strength (Indirect tensile strength) & flexural strength has been observed. In this experimental study, the effect of MDP in concrete on strength is presented.

Keywords – Marble Dust Powder (MDP), cement, Compressive strength, Tensile strength, flexural strength

1. INTRODUCTION

It has been approximated that into the millions a lot of MDP are created during quarrying globally. Hence usage of stone powdered has become an important alternative material towards the effective usage in tangible for enhanced solidify qualities of tangible. Marble is a metamorphic stone as a result of the modification of a genuine limestone. The cleanliness of the stone is accountable for its colour and overall look it is white if the limestone is consisting completely of calcite (100% $CaCO_3$). Marble is used for development and decoration; stone is resilient, has a respectable overall look, and is consequently in great demand. Chemical, glass beads are crystalline stones consisting primarily of calcite, dolomite or course nutrients. The other mineral constituents vary from origin to origin. The main impurities in raw limestone (for cement) which can affect the properties of finished cement are magnesia, phosphate, leads, zinc, alkalis and sulphides. A variety of MDP is produced during the cutting process. The result is that the huge of stone spend which is 20% of total stone quarried has achieved as high as large numbers of plenty. Making these spend products to the environment straight can cause ecological issue. Moreover, there is a limit on the accessibility of natural total and nutrients used for making concrete, and it is necessary to reduce energy intake and exhaust of co2 causing from development procedures, fix for your issue are desired through utilization of MDP as limited alternative of Beaverton slag concrete. In India, MDP is settled by sedimentation and then dumped away which results an environmental pollution, in addition to forming dust in summer and threatening both agriculture and public health. Therefore, utilization of the MDP in various industrial sectors especially the construction, agriculture, glass and paper industries would help to protect the environment. waste can be used to generate new items or can be used as admixtures so that organic sources are used more effectively and the surroundings remains safe and secure from waste remains.

2. MATERIAL, SITE DESCRIPTION, AND EQUIPMENTS

Material

- **Cement:**

  OPC (ordinary Portland cement) - conforming to IS:8112-1989 (BIS, 2005) is used in this study.

- **Coarse aggregates:**

  Coarse aggregates of size 10-20 mm is used.

- **Fine aggregates:**

  Natural sand is used, passing through 2.36 sieve.

- **Marble waste powder:**

  In marble stone industry waste is generated that waste is used as marble waste powder.

- **Sp 430:**

  Super plasticizer (sp 430) will be used for low water to cementious binder ratio.

3. LITERATURE REVIEW

The aim of this research is to develop high strength concrete with the utilization of a waste product MDP. MDP possesses good pozzolanic material is the activity and is a good material for the production of concrete Also now a day's one of the great applications of MDP is in various structural fields as in reinforced cement concrete, which is gaining popularity because of its positive effect on various properties of concrete. Although strong attention in analysis of MDP usage has been designed during last six to seven years, the newest study is given below.

[1] Manju Pawar et al (2014) A Study has been conducted on Periodic Research, The Significance of Partial replacement of Cement with Waste Marble Powder. They found that the effect of using marble powder as constituents of fines in mortar or concrete by partially reducing quantities of cement has been studied in terms of the relative compressive, tensile as well as flexural strengths. Partial alternative of tangible by varying portion of stone powdered reveals that improved spend stone powdered (WMP) ratio outcome in improved strengths of the mortar and tangible. Leaving the spend products to the environment directly can cause environmental problem. Hence the outcome, The Compression durability of Concrete are improved with inclusion of spend stone Powder up to12.5 % substitute by bodyweight of tangible and further any inclusion of WMP the compressive durability reduces. The Tensile durability of Concrete are improved with inclusion of spend stone powdered up to 12.5 % substitute by bodyweight of tangible and further any inclusion of WMP the Tensile durability reduces. Thus, they found out the optimum amount for alternative of MDP with tangible and it is almost 12.5 % tangible for both compressive & tensile durability.

[2] B. V.M. Sounthararajan et al (2013) A Study has been conducted on Effect of the Lime Content in MDP for Producing High Strength Concrete. They found that the MDP up to 10% by weight of tangible was examined for solidified tangible qualities. Furthermore, the effect of different amount alternative of MDP on the compression durability, breaking tensile durability and flexural durability was analysed. It can be observed that the impact of fine to rough total rate and cement-to total rate had a higher impact on the development in durability qualities. An incredible increase in the compression durability of 46.80 MPa at 7 days for 10% alternative of MDP in tangible content was mentioned and also revealed an improved technical property compared to managed tangible.

[3] C. Corinaldesi V et al (2010) Marble as a building material especially in palaces and monuments has been in use for ages. However, the use is limited as stone bricks in wall or arches or as lining slabs in walls, roofs or floors, leaving its wastage at quarry or at the sizing industry generally unattended for use in the building industry itself as filler or plasticizer in mortar or concrete. The result is that the big which is 40% of complete stone quarried has achieved as high as large numbers of plenty. This huge unwatched huge of stone spend made up of very excellent contaminants is nowadays one of the ecological problems around the world.

[4] Sadek et al (2016) Intended to find the optimum mix design by adding marble powder, granite powder, and stone powdered þ marble powdered of 20%, 30%, 40%, and 50% of cement weight in mixes where the concrete bodyweight is kept continuous at 400 kg/m3. The 28-day compression durability was revealed to enhance at prices of 1.7%, 3.9%, and 9.5%, with stone powdered included at the prices of 30%, 40%, and 50%; it was 7.8%, 23.1%, and 39.3% with value was 50% for stone powdered, marble powdered, and stone powdered marble powder; in particular, they revealed that the workability reduces with improved powdered content.

[5] Chavhan and Bhole (2014) Produced concrete mixtures by replacing gravel with marble powder with the rates varying between 5% and 50%, and reported that 14-day and 28-day compressive strength values of a sample free of marble powder were 30.14 MPa and 28.16 MPa, respectively; the 28-day splitting tensile strength value was 4.65 MPa. In comparison, the compression durability principles of the example that included 50% stone powdered for the same days were considered to be 33.13 MPa and 35.67 MPa, and the breaking tensile durability value was 5.72 MPa.

[6] Soliman (2013) Produced concrete mixtures by replacing cement with marble powder with the rates of 2.5%, 5%, 7.5%, 10%, 12.5%, 15%, 17.5%, 20%, and produced 115 _ 40 _mm slabs samples; they observed a 24.88% increase in the 28-day compressive strength for 2.5% replacement rate as compared to the control sample, and a 8% increase for a 7.5% replacement rate. They reported that while 28-day tensile strength was 3.8 MPa for 5% replacement rate, it reduced to 2 MPa for 20% replacement rate. They reported that compressive strength reduced for every replacement rate beyond that rate.

[7] Omar et al (2012) Emphasized that SiO2, which is also present in marble, reacts with Ca(OH)2, the compound that hydrates the cement with water. This reaction further increases the compressive strength.

[8] Prassianakis And Prassianakis (2004) and Prassianakis et al (2000) Noted that marble is the metamorphosed product of limestone deposits subjected to heat and pressure and is chemically simple. **Vuk et al (2001)**, defined marble dust as a pozzolan. He pointed out that the calcium carbonate (CaCO3) in marble dust reacts with tricalcium aluminate (C3A) in cement, which is present in large amounts. This reaction increases the hydration speed and compressive strength of cement.

3.1 Replacement of fine aggregates with waste marble

[9] Gameiro et al (2014) studied the impacts of finely aggregated marble pieces on the durability of concrete. They substituted granite, basalt, and river sands with marble dust at volume ratios of 20, 50, and 100%, respectively. They found that substitution with 20% waste marble reduced the water absorption by capillary action. The 28-day carbonation depth was 8.5 mm in the reference granite sample and 7.2, 6.5, and 5.5mmin the samples substituted with 20, 50, and 100% marble waste, respectively. The density changes in the marble substituted samples (~1.3%) were almost imperceptible, whereas the drying shrinkages decreased within 20 days when all sand types were replaced with marble dust.

From an environmental sustainability perspective

[10] Uygunoglu et al (2014) analysed the effects of aggregated marble pieces On the mechanical properties of self-compacting concrete. They formed mixtures with water-to-concrete (w/c) ratios of 0.31, 0.34, 0.37, and 0.40, using recyclable and waste marble aggregates. The 7-day compressive strength of the recyclable aggregate mixture with 0.31 w/c was 49 MPa, compared to 44 MPa for the marble aggregate sample. Similarly, the 28-day compressive strengths of the samples produced from recyclable and marble aggregates were 54 and 53.5 MPa, respectively. The compressive strength decreased with increasing w/c ratio.

[11] Talah et al (2015) Researched the effects of marble dust on the mechanical properties of high performance concrete (HPC). They tested a reference sample with no marble dust and an HPC sample with 15% marble substitution. The compressive strengths on days 7, 28, 90, 180, and 365 were measured as 26, 38, 44, 46, and 48 MPa, respectively, in the reference sample, and as 39, 52, 58, 62, and 65 MPa, respectively, in the test sample. They emphasized that thedurability of the concrete substituted with 15% marble dust can be further enhanced. The replacement of fine aggregates with marble dust in concrete production was investigated by **Hebhoub et al (2011).** They prepared marble dust samples at replacement ratios of 25, 50, and 100%, and observed that changing the marble dust content does not alter the mass density. The 28-day compressive strengths of samples with marble-replacement ratios of 25, 50, and 75% were increased by 22.2, 16.84, and 16.84%, respectively (relative to the reference sample containing no marble dust). Moreover, the 90-day splitting tensile strengths were increased by 13, 33, and 11%, respectively. However, both compressive and splitting tensile strengths were decreased in the 100%-substituted sample. They also observed that the workability decreases with increasing substitution ratio of the marble dust. At 100% substitution ratio, the workability declined by 80%. **Hebhoub et al** concluded that replacing fine aggregates with marble dust significantly increases the compressive and tensile strength of concrete.

[12] Belachia and Hebhoub (2011) Studied the use of waste marble aggregates in concrete production. For this purpose, they generated mixtures at marble substitution ratios of 25, 50, 75, and 100%. The highest compressive strength was achieved at the 25% substitution ratio. Maintaining the ratio at 0.45 w/c, they found that the samples not containing waste marble have a compressive strength of 33 MPa, whereas in samples containing 25% waste marble, the compressive strength increased to approximately 36 MPa. These researchers concluded that waste marble is a suitable alternative material to natural aggregates.

[13] Corinaldesi et al (2010) Explored the necessary characteristics of marble dust in concrete production. For this purpose, they replaced the fine aggregates in concrete with 10 and 20% marble dust. They concluded that marble dust negatively affects the mechanical properties of concrete. Although the hydration time was unaffected in samples containing 10% marble dust and no super plasticizer, the compressive strength decreased by up to 10% as the concrete aged. In contrast, when the 10% marble dust sample was supplemented with super plasticizer, the marble dust beneficially acted as a sealant. The above data were approximated from the relevant graphics in their study.

[14] Omar et al (2012) Replaced the sand in concrete with marble dust at ratios of 5, 10, and 15% and compared the strengths of the modified concretes. Marble dust at a ratio of 15% increased the modulus of elasticity by 1.2e5.1%, but decreased the concrete's workability. At any ratio, the marble dust noticeably increased the compressive strength on days 7, 28, and 90. In samples with 350 kg/ m3 cement density and 5% marble dust substitution, the compressive strengths on days 7, 28, and 90 were increased by 10, 5, and 5%, respectively, relative to the reference sample with no marble dust. The corresponding increases were 17, 15, and 15% in the 10% marble dust sample, and 22, 17, and 17% in the 15% marble dust sample. Moreover, the splitting tensile strengths in all marble dust samples increased by 10%.

3.2. Substitution of coarse aggregates with waste marble

[1] Andre et al (2014) Applied marble chippings as a coarse aggregate and investigated the properties of the resulting concrete. They varied the replacement ratio of the marble chippings as 20, 50, and 100% and found that increasing the replacement ratio decreased the 28-day compressive strength. They also determined the immersion values of their samples and reported similar absorptions to the reference sample, possibly because the marble and natural aggregates have similar microstructures. The addition of coarse marble aggregates considerably increased the chloride migration coefficient of the mixtures. The durability and carbonation depths were also similar in the test and reference samples.

[2] Binici et al (2008) Added marble chippings as coarse aggregates and studied the mechanical properties of the modified concrete. The marble aggregate sizes were varied as 19, 12.7, 9.5, and 4.5 mm. Replacing the coarse aggregates with marble aggregates reduced the chloride penetration depth and 28-day sulphate resistance by up to 70% relative to the reference sample. On day 365, the compressive strength of all samples was 49% higher than on day 7 and 55% higher than that of the reference sample. In addition, the bending and splitting tensile strengths at day 28 were 64 and 57%, higher, respectively, in the test samples than in the reference sample. These researchers clarified that aggregated marble chippings improve the mechanical properties of conventional concrete.

[3] Wu et al (2001) Analysed the mechanical properties of high strength concrete embedded with coarse aggregates of different w/c ratios (0.26, 0.44, and 0.55). The compressive strength of the samples decreased with increasing w/c ratio. In the sample with 0.44 w/c ratio, the compressive strength, splitting tensile strength, modulus of elasticity and flexural strength were 28, 49, 8, and 12% lower, respectively, than in the sample with 0.26 w/c ratio. The corresponding losses in the sample with 0.55 w/c ratio were 77, 80, 16, and 16%, respectively. The researchers concluded that marble pieces as coarse aggregates can enhance the mechanical properties of concrete when incorporated at low w/c ratios.

[4] Sudarshan and Vyas (2016) Studied the feasibility of using coarse aggregates of waste marble instead of limestone. For this purpose, they prepared mixtures with substitution ratios of 20%, 40%, 60%, 80% and 100%. The compressive strength increased up to 80% substitution, and thereafter decreased by 8%.

[5] Andre (2012) Substituted primary aggregates with coarse aggregates of waste marble chips. Over 28 days, the compressive strength declined at substitution ratios exceeding 50%, whereas in the reference sample, the compressive strength increased up to this ratio. However, the water absorption values during immersion and carbonation were similar in the test and reference samples.

[6] Binici et al (2008) Found that coarse aggregates of marble dust increase the flexural strength of concrete. However, Wu et al. (2001) argued that the flexural strength decreases at higher w/c ratios. This contradiction is presumably caused by the different w/c ratios of the mixtures prepared by the researchers for their experimental studies. At ratios of 50e80%, the substitution of waste marble as coarse aggregates appears to improve the mechanical properties of concrete; however, further research is required to consolidate this idea. New comprehensive studies on different types of marble wastes will assist in verifying this idea and developing new industrial applications.

4. Studies evaluated within the scope of this review

4.1 Substitution of cement with marble dust

[1] Shirule et al (2012) Substituted cement with marble dust and investigated how the substitution affected the mechanical properties of concrete. They concluded that marble dust at a cement replacement ratio of 10% increased the 28-day compressive strength by 17% and the tensile strength by 11.5%.

[2] Rana et al (2015) Studied the sustainable use of marble slurry in concrete production. For this purpose, they replaced cement with 5, 10, 15, 20, and 25% marble slurry. On days 7, 28, and 90, the compressive strengths of the reference sample were 36, 43, and 51 MPa, respectively. The respective strengths of the sample containing 5% marble slurry were 50, 42.5, and 35.5 MPa. The compressive strength decreased with increasing substitution ratio of the marble slurry on all three test days. On days 7, 28, and 90, the flexural strength was 5.4, 6.5, and 6.8 MPa, respectively, in the reference sample, and approximately 5.3, 6.4, and 6.5 MPa, respectively, in the sample substituted with 5% marble slurry.

[3] Topçu et al (2009) Investigated the effects of marble dust on the mechanical properties of self-compacting concrete. They replaced cement with marble dust at ratios of 150 (30%), 200 (40%), 250 (50%), and 300 kg/m3 (60%). As more of the cement was replaced with marble dust, the compressive and bending strengths of the concrete decreased. Marble replacement at 300 kg/m3 reduced the compressive and splitting tensile strengths by 51 and 47%, respectively. According to these researchers, increasing the marble dust ratio also reduced the slump flow (mm).

[4] Belaidi et al (2012) Investigated the effects of natural pozzolana and marble dust on self-compacting concrete. They prepared two series; one replacing cement with pozzolana at ratios of 5, 10, 15, 20, and 25%, and the other prepared with marble at replacement ratios of 10,15, 20, 30, and 40%. In both series, a replacement ratio of 40% decreased the compressive resistance by 50% and increased the slump value.

[5] Geso glu et al (2012) Stated that the replacement of cement with marble dust at 20% or higher adversely affects the mechanical concrete specifications of concrete. These disparate results are thought to be caused by the different C3A contents of the cement used in the various studies.

Geso glu et al (2012), Ergun (2011), Uysal and Sumer (2011), Uysal and Yılmaz (2011) Accordingly determined the appropriate concrete replacement ratio as 5%. There are two possible explanations for this effect. First, the silica in the marble dust (if sufficient) reacts with the Ca(OH)2, which results from the hydration reaction between the cement and water.

An extra binding phase emerges from the additional pozzolanic properties. Second, the tricalcium aluminate (C3A) in the cement reacts with the calcium carbonate (CaCO3) in the marble dust to form calcium carboalumination. This compound increases both the hydration speed of the cement and the compressive strength.

[6] Rodrigues et al (2015) Remarked that super-plasticizer additives are required to obtain the desired performance of cement partially substituted with marble dust. In the absence of super-plasticizers, they reported negative effects on the mechanical specifications of concrete at replacement ratios up to 10%. All of these studies suggest that substituting cement with more than 10% marble dust decreases the compressive strength of the concrete. High contents of marble dust are considered to increase the capillarity structure of the concrete. According to the reviewed studies, marble dust can improve the mechanical specifications of the concrete when substituted at ratios of 5e10%.

5. Result and discussion

5.1. Workability of concrete

Workability of control concrete mixture and blended concrete mixtures incorporating marble powder with cement, sand and amalgam of cement & sand was measured at 10% and 15% proportions. As per IS: 7320-1974 [40], the workability was evaluated for the cement/binder concrete through slump cone test. Table 4 shows replacement level, mix designation slump value of mixes. Replacement of marble powder with cement and sand has no effect on workability. It was observed that slump decreases with the replacement of cement by marble powder. Though, marble powder has higher specific area as compared to Portland cement. The replacement resulted in lower workability due to increased friction. But it was observed that slump increases with the replacement of sand by marble powder. It is due to fine filler effect of marble powder.

5.2. Compressive strength

Fig. 2 represents compressive strength of concrete mix at several replacement levels of sand with marble powder. It was noticeable that, with increase of marble powder content up to 15%, there was a significant increase in compressive strength. Marble powder is a micro fine filler; due to this filler effect, concrete strength is enhanced. The use of marble powder is more effective as a substitute for sand. It was observed that there was an increase in the compressive strength in replacement of sand with 10% of marble powder at curing age7, 28, 56 and 90 days was 10.74%, 11.93%, 15.07% and 15.43% and respectively at 15% was 17.57%, 20.97%, 20.34% and 20.33%. The concurrent observations were made by Aliabdo et al. [8]; Binici et al [43]

It can be noticed that in substitution of marble powder with cement at all substitution levels, the compressive strength of concrete slightly decreases as indicated in Fig. 3. It is due to drop in tricalcium silicate (C3S) and dicalcium silicate (C2S) cementing materials, which play a main role for strengthening concrete. The increase in compressive strength at the curing age of 7, 28, 56 and 90 days was 7.17%, 8.44%, 8.82% and 10.15% for specimens with 10% marble powder as cement replacement compared to those without marble powder concrete. The drop in compressive strength as compared to the control mix was observed at 15.0% marble powder addition was 6.77%, 0.21%, 4.8% and 5.84% at 7, 28, 56 and 90 days. Aliabdo et al [8]; Shirule et al. [44] found that compressive strength increased slightly up to 15% cement replacement of marble powder by weight as compared to the mix without marble powder concrete. This is due to pore filling effect which strengthens properties of the transition zone (TZ) surrounding aggregate in waste marble powder. This happens due to lower w/p ratio due to failure in TZ .

The compressive strength of concrete containing 0%, 20% and 30% marble powder as partial substitution of sand and cement amalgam at 7, 28, 56 and 90 days curing ages was obtained. Fig. 4 depicts the effects of marble powder as partial replacement of cement and sand amalgam. It can be observed that, at all replacement levels of sand and cement amalgam, partial replacement ratio of 20% by marble powder has increased the compressive strength of concrete at the curing age of 7, 28, 56 and 90 days was 15.88%, 14.91%, 15.11% and 15.23% and respectively at 30% was 4.83%, 4.65%, 5.15% and 4.37%.

5.3. Split tensile strength

The splitting tensile strength of the concrete containing 0%, 10% and 15% marble powder as partial substitution of sand was observed at 7, 28, 56 and 90 days curing period. It can be observed that highest split tensile strength can be achieved with 10% of marble powder as sand substitution and slightly low results were measured with 15% marble powder as compared to 10% marble powder at all curing ages. Typically, low porosity is responsible for this improvement in split tensile strength with utilization of marble powder as a micro filler material. The utilization of marble powder as a sand substitution improves the split tensile strength of concrete in comparison of control mix.

5.4. Ultrasonic pulse velocity

Observations of partial replacement of sand, cement and amalgam form with marble powder at curing age of 28 days. In the insignificant effect can be noticed on the result of the ultrasonic pulse velocity with replacement of marble powder as sand, cement, and amalgam. The insignificant variance in results is due to the ultrasonic pulse velocity proportionality with the fourth root of concrete compressive strength.

5.5. Accelerated carbonation test

It is reflected that carbonation of concrete decreased with the usage of waste marble powder in replacement of sand and cement. Carbonation decreases on replacement of sand and cement amalgam with marble powder but it was slow as compared to sand replacement. For the 10% sand replacement, results were lower at 14 and 28 days exposure period and also lower for the 56 days exposure. For 10% cement and sand amalgam replacement too, results were lower at 14, 28 and 56 days exposure period but depth of carbonation in concrete for cement and sand amalgam replacement was higher as comparison of sand replacement. The trends of decrease were similar at all exposure period of carbonation.

6. Conclusions

In this review, the use of waste marble in concrete production was examined under three main topics. Studies on the substitution ratios of waste marble were analysed and their differences and similarities were assessed. The aim was to identify a common substitution ratio and to provide a coherent picture of the selected studies for readers. Replacing cement with 5e10% marble dust improves the mechanical properties of the concrete, while reducing the CO_2 emissions of cement production by 12%. Supplementing up to 75% of the cement weight with marble dust as a filler material enhances the compressive strength by 42% and the splitting tensile strength by 42%. In coarse aggregate form, marble waste replacement exerts more positive impacts as the w/c ratio reduces. In fine aggregate form, marble dust achieved the best results at replacement ratios of 50 and 75%. In these cases, the compressive and splitting tensile strengths were increased by 20to26 and 10to15%, respectively. In coarse aggregate form, marble dust increases the compressive strength by

20e70% and the splitting tensile strength by 50to80%. Used as filler material, marble dust increase the compressive and splitting tensile strengths of concrete by 42 and 41%, respectively. Replacing the cement in concrete by 20% marble dust yielded the least favourable results.

To improve the economic recovery of wastes, concrete researchers have proposed substituting a proportion of concrete with marble dusts and slurries of by-products/wastes from the waste ponds of workplaces and plants. Other studies have investigated the recovery of useless marble wastes by grinding them into coarse aggregates that can be substituted into concrete. When substituted at appropriate ratios, marble exerts no adverse effects on concrete quality but may enhance the mechanical specifications. In microstructure investigation, control concrete and blended concrete specimens do not show any significant result which confirms that marble powder has no evident role in hydration process. The durability parameters of marble powder showed improvement which makes it suitable as an additive in concrete. The study suggests that any further possible combinations can result deleterious for mechanical and durability properties. According to the reviewed studies, the use of marble in concrete production benefits the economy and reduces environmental pollution. Aggregates of marble wastes appear to be especially suitable for concrete production in ready-mixed concrete plants.

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