# UTILIZATION OF MARBLE WASTE FOR CONSTRUCTION PURPOSES

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**Abstract**

***Gradual depletion in the natural resources has posed great problem to the construction sector in the recent times. A recent survey has shown that the recent boom in the construction sector will not decrease, but ready rise in the number of housing projects will be quite evident in the 5-10 years. The cost of cement, sand aggregate has gone sky-high, thereby making it quite unaffordable now. Though M-sand and Quarry dust has replaced natural sand in recent times, other than conserving the later, the construction sector has seen no noticeable change in the price. Owing such an increase in the price, scientists and engineers have recently sought to research and study the properties and advantages of using other materials as a satisfactory substitute of cement, sand and aggregate. Hence the detailed study in this project is of using marble waste as a partial substitute of fine aggregate for increasing the strength of concrete.***

***Marble waste is byproduct of marble production industries. Over 300 Million tones of industrial wastes are being produced by annum by chemical and agricultural process in India. Its mass production was found to create large scale environmental pollution. In addition these materials cause problems of disposals and health hazards. To reduce disposal and air pollution problems emitting from these industrial wastes, it is most essential to profitable building materials from them. In this experiments study, the effects of using marble wastes (MW) as a fine material on the mechanical properties of 0%, 10%, 15%, 20%, 25% by weight. This project concerned with experimental investigation of using marble waste on strength of concrete and finding out the optimum percentage of partial replacement by replacing fine aggregate via 0%, 10%, 15%, 20% and 25% by marble waste in $M_{20}$ mix.***

***Keyword: Marble waste, concrete, replacement of sand, economic feasibility.***

## 1.INTRODUCTION

### *1.1. general*

Marble has commonly used as a building material since the ancient times. The industries disposal of the marble waste material, consisting of marble pieces and very fine powder, today constitutes one of the environmental problems around the world. Rajasthan being famous for its marble deposits, it alone produces 95% of the total marble produce of the country.

Studies have been conducted on the performance of the concrete containing waste marble and its addition into self compacting concrete as an admixture or sand. And also its utilization in the mixture of asphaltic concrete and its utilization as an addictive in cement production, the usage of marble as a coarse aggregate and as an fine aggregate passing through 1mm sieve. Generally, in literature waste marble dust has been replaced with either all of the fine aggregate (0 to 4mm) or passing 1mm sieve potential usage of this waste material. There for, the aim of this current study is both to avoid the environmental pollution and to investigate usability of the marble waste partially instead of vary fine sand passing through a 0.475mm sieve at proportions 0%, 10%, 15%, 20% and 25% by weight on the concrete. In this way, we will help to protect the environment by consuming the waste marble obtained as a by-product of marble sawing and shaping process in the factories those operating in our region.

### *1.2. environmental hazard*

Marble mining at Makrana, Rajasthan is classic example of unscientific mining and important waste disposal regardless of aesthetics, proper land use practices etc. specifically, the improper waste disposal has caused land degradation and flooding of water, visual impact, loss of aesthetics, pollution, health and safety hazards. Marble slurry imposes serious threats to ecosystem, physical, chemical and biological components of environment. Problems encountered are;

- When dumped on land, it adversely affects the productivity of land due to decreased porosity, water absorption, water percolation etc.
- When dried, the fine particles (size is less than 363 μ) become air borne and cause severe air pollution.
- Apart from occupational health problems, it also affects machinery and instruments installed in the industrial areas. Slurry dumped areas cannot support any vegetation and remain degraded.
- During rainy season, the slurry is carried out to rivers, drains, roads, and water bodies affecting quality of water , reducing storage capacities and damaging aquatic life.
- Due to long term deposition of land the finer particles block flow regime of aquifers thus seriously affecting underground water availability.
- The heaps of slurry remains scattered all round the industrial estate are an eye sore and spoil aesthetics of entire region. Subsequently tourism and industrial potential of the state is adversely affected.

### *1.3. utilization*

Sustainable development is characterized by application of industrial wastes to reduce consumption of natural resources and energy and pollution of environment by means of Green concrete. Marble wastes as fine aggregate can be used as filler and helps to reduce the total void content in concrete. Though reaction with the concrete admixture, quarry rock dust improved pozzolanic reaction, micro aggregate filling and concrete durability.

An attempt has been made to durability studies an green concrete compared to natural sand concrete. Resistance to sulphate attack was greatly enhanced in concrete. Application on green concrete is an effective way to reduce environmental pollution by utilization of waste marble, reducing sand mining and improving durability of concrete under several conditions. This paper represents the feasibility on the usage of marble waste as a satisfactory substitute for natural sand in concrete.

### *1.4. objectives*

Replacement of fine aggregate with marble waste material and test the compressive strength of specimen after 28 days of curing.

- To determine the use of marble waste as a substitute for fine aggregate in concrete mix.
- To study the physical and chemical properties of marble waste.
- Compare the strength of the normal concrete and the proposed marble waste mixed concrete.
- To investigate the utilization of marble waste and influence of this on concrete made with different be produced.
- To check the economic feasibility.

## 2.PROPERTIES OF MARBLE

Metamorphic rocks like marble is produced from limestone by pressure and heat in the earth crust. This alteration can cause chemical change or structural modification to the minerals making up the rock. Structural modification may involve the simple re-crystallization of minerals into layers or the aggregation of minerals in to specific areas within the rock. The pressure and heat in the earth’s crust cause limestone to change in texture and makeup. This process is called re-crystallization. Fossilized materials in the limestone, along with its original carbonate minerals, re-crystallize and form large, coarse grains of calcite.

Impurities present in limestone during the re-crystallization period affect the mineral composition of marble which is formed. Impurities incorporated during the original carbonate precipitation especially from the cold marine water solution form characteristics of colors. Accordingly a pure calcite marble is white but tiny amounts of impurities such as iron and magnesium

color marble significantly green. Graphite (algae) colors marble dark, pyrite commonly colors marble greenish grey, finely disseminated hematite will color marble pink.
At relatively low temperature silica impurities in the carbonate minerals form masses of chert or crystal of quartz. At higher temperature, the silica reacts with the carbonates to produce diopside and forsterite. At a very high temperature rare calcium minerals such as brnite, monticellite and rankinide forms in the marble. Serpentine, talc and certain other hydrous minerals may be produced if there is presence of water. The presence of iron, alumina and silica my result in the formation of hematite and magnetite.

### *2.1. physical properties of marble*

Physically, marble is re-crystallized hard, compact, fine to very fine grained metamorphosed rocks capable of taking shining polish. The properties are shown below;

**Table 2.1 Physical Properties**

| | |
|---|---|
| Hardness | 3 to 4 Mohr's scale |
| Density | 2.55 to 2.7 Kg/cm$^3$ |
| Compressive strength | 70 to 140 N/mm$^2$ |
| Modulus of rupture | 12 to 18 N/mm$^2$ |
| Water absorption | Less than 0.5% |
| Porosity | Quite low |
| Weather impact | Resistant |

### *2.2. chemical properties of marble*

Marbles are composed predominantly of calcite, dolomite or serpentine minerals. Quartz, muscovite, tremolite ,actinolite, micro line, chert ,talc, garnet, osterite and biotite are the major mineral impurities whereas $SiO_2$, limonite, $Fe_2O_3$, manganese, $3H_2O$ and $FeS_2$ (pyrite) are the major chemical impurities associated with marble.
Limestone is made up of varying proportion of chemicals such as calcium carbonate ($CaCO_3$), magnesium carbonate($MgCO_3$), silica($SiO_2$), alumina($Al_2O_3$), iron oxide($Fe_2O_3$), sulphate ($SO_3$), and phosphors($P_2O_5$) with calcium and magnesium carbonate being the two major compounds. The main impurities in raw limestone (for cement) which can affect the properties of finished cement are magnesia, phosphate, leads, zinc, alkalis and sulphide.

**Table 2.2 Chemical Properties**

| | |
|---|---|
| Lime (CaO) | 28-32% |
| Silica ($SiO_2$) | 3-30% (varies with variety) |
| MgO | 20-25% |
| FeO + $Fe_2O_3$ | 1-3% |
| Loss of ignition | 20-45% |

### *2.3. uses of marble*

- Marble slurry is used for replacement of other material and saves the material.
- Marble slurry used to increase the strength in concrete.
- Marble slurry we get in nominal or free of cost.
- Marble scrape is used to make attractive flooring in minimum cost.
- cost of construction is decreased because costly material is replaced by marble waste.
- In Fly ash brick if lime is replace by marble waste so increase the strength of brick.
- Binding property of marble slurry is very good.

## 3.MATERIALS USED

- Cement : Ordinary Portland cement of 53 grade
- Marble pieces : Waste marble pieces were obtained in dry form from deposits in construction sites. The pieces had to be crushed to obtain the grade similar to the aggregate before being used. The crushed marble thus obtained was sieved through a set of sieves ranging from 4.75mm to 300 μ IS sieves.
- Fine Aggregate : Natural sand (maximum size 4.75mm) was used.
- Coarse Aggregate : Aggregate of maximum size 20 mm was used.
- Water : Portable drinking water is used.

## 4.PRELIMINARY TESTS

### *4.1. tests on cement*

#### *4.1.1. Fineness of cement*

This test is used for checking the proper grinding of cement. For testing fineness of cement,

- Take 100 gm of cement (W) and it is continuously passing through standard sieve90µ for 15 minutes. The residue is weighed (w).
- Fineness = (w/W) x l00
- Limit = 5% to 10%

#### *4.1.2. Specific gravity of cement*

- Dry the Le-Chatelier flask and fill the flask with kerosene oil to appoint on the stem between zero and one ml.Record the level of kerosene oil in the flask as initial reading.
- Introduce about 64 gm of cement into the flask so that the level of kerosene rises above the bulb portion .Cement should not be allowed to adhere the sides of the flask above the liquid.
- Stopper is inserted into the flask and roll it gently in an inclined position. Expel the air from the cement until no further air bubbles rise to the surface of the liquid.
- Note down the level of kerosene in the flask.

Displaced volume of kerosene = Final reading - Initial reading

Specific gravity = Weight of cement / Displaced volume of kerosene

#### *4.1.3. Standard consistency test*

The test was done to determine the quantity of water required producing a cement paste of standard consistency; the standard consistency is that which permits the vicat plunger to penetrate to a point to 5-7mm from bottom of vicat mould, when tested as detailed below.

- Take 400 gm of cement.
- Take a weighted quantity of water in a jar.
- Prepare a paste with the cement and water.
- Fill the vicat mould with a paste after keeping the mould over a non porous plate. Take care to see that the time of gauging is not less than 3 minutes and not more than 5 minutes. The time of adding water to the dry cement until commencing to fill the mould is counted and noted as gauging time.
- After completing filling the mould, smooth off the surface of the paste, making n level with the top of the mould. Slightly make the mould to expel air.
- Place the mould under the vicat plunger and lower the plunger gently to touch the surface of the paste. Then quickly release it, allowing it to penetrate into the paste under its own weight.
- Note the penetration of the plunger on the scale provided in the vicat apparatus, if it is between 5-7 mm from the bottom, water added is correct. Otherwise repeat the test as the above by preparing paste with varying % of water until the required penetration is obtained.

#### *4.1.4. Initial and Final setting time*

- Take 400gm of cement and prepare a cement paste with 0.85 times the water required to give a paste of standard consistency.
- Keep the gauging time between 3-5 minutes. After adding water to the cement, start the stop watch.
- Place the mould under the rod bearing the needle for finding the initial setting time.
- Lower the needle gently to touch the surface of the paste and then release quickly.
- In the beginning, the needle completely penetrates the test block. Repeat the procedure until the needle fails to pierce the block beyond 5± 0.5 mm measured from the bottom of the mould.
- The time elapsed between when water is added to the cement and the time at which the needle fails to pierce the block to a point 5±0.5 mm measured from the bottom of the mould is initial setting time.

- For determining the final setting time, replace this needle by the needle with annular attachment.
- The cement is considered finally set when upon applying the needle gently to the surface of the test block, the needle makes an impression on surface but the attachment fails to make impression. The time when water is added to the cement and the time at which the needle makes an impression on the surface of the test block but the attachment fails is the final setting time.

#### *4.1.5. Compressive strength of cement*

- Measure the given cement and standard sand in the proportion 1:3 by weight for 3 mortars cubes (600 gm of cement and 1800 gm of sand) and mix it dry with a trowel in a tray. The quantity shall be combined weight of cement and sand.
- Add water and mix it until the mixture is of uniform color and fill the mortar in the cube mould prod it with the help of poking rod. The mortar shall be produced 20 times in about 8 seconds to ensure elimination of entrapped air. If vibrator is used, the period of vibration shall be 2 minutes at a specific speed of 12000 vibrations per minute.
- Smooth off the top surface of the cube with the help of a trowel and keep for 24 hours. After 24 hours remove the mortar cube from the mould and immerse in water till testing, test the cube after 7 days in compression testing machine. The rate of loading shall be uniform at 350 kg/cm$^2$ minutes. Test at least 3 cubes and their average value shall be taken as the test result.

Compressive strength of cement = load /surface area

### *4.2. tests on aggregate*

#### *4.2.1. Specific gravity test*

- Fill the container with the given aggregate and then over fill with water.
- Note the weight of container with aggregate and water.
- Empty the container and allow the aggregate to drain.
- Refill the container with water and take its weight.
- Place the aggregate on a dry cloth and gently surface dry with the cloth keeping it away from sunlight.
- Take weight of the surface dried aggregate.
- Place the aggregate in the oven in a shallow tray at the temperature of 100 to II 0°c for 24 ± ½ hours.
- Cool the aggregates and note down the weight of oven dried aggregate. 6.2.2 Particle size distribution and grading.

#### *4.2.2. Particle size distribution and grading*

The text shall be carried out as described in IS 2386 part 1 -1963. The sample shall be dried and brought to an air - dry condition, weighed and sieved successfully on appropriate sieves .For sieving by hand shake each sieve shall be kept in order over a clean tray for a period not less than 15 minutes. Forward, backward, left to right, circular- clockwise and anti-clockwise shakings are done and with frequent jarring, so that material is kept moving over the sieve surface in frequently changing directions. Material shall not be taken forced through the sieve by hand pressure with fingers against the side by the sieve. Light brushing with soft brush on the underside of the sieve may be done to clear the sieve openings.

a) Coarse aggregates: 2 kg of coarse aggregate shall be taken. Arrange the sieve in the order of 80 mm, 40mm, 20mm, 10mm and 4.75 mm with 80mm at the top. Carryout sieving for 15 minutes and obtain the weight of aggregate retained on each sieve.
b) Fine aggregate: 1 kg of fine aggregate shall be taken. Arrange the sieve in the order 4.75mm, 2.36mm, 1.18mm, 600μ, 300μ, with 4.75mm sieve at the top. Carryout sieving for 15 minutes and obtain the weight of aggregate retained on each sieve and Plot the graph.
c) Fine marble waste: 1kg of fine marble shall be taken. Arrange the sieve in the order of 4.75mm, 2.36mm, 1.18mm, 600μ, 300μ, with 4.75mm sieve at the top. Carryout sieving for

15 minutes and obtain the weight of aggregate retained on each sieve. Plot the graph.

#### *4.3. test data for materials*

The result obtained from preliminary tests conducted for cement and fine aggregate are tabulated below.

**Sieve analysis**

As part of the preliminary tests, the sieve analysis done separately for coarse aggregate, fine aggregate and marble waste has been tabulated separately for each is shown below.

#### *4.3.1. Coarse aggregate*

**Table 4.1 Data obtained for coarse aggregate**

| Sieve size (mm) | % Passing |
|---|---|
| 80 | 100 |
| 40 | 100 |
| 20 | 76.17 |
| 10 | 4.51 |
| 4.75 | 0.85 |
| Pan | 0 |

#### *4.3.2. Fine aggregate*

**Table 4.2 Data obtained for fine aggregate**

| Sieve size (mm) | % Passing |
|---|---|
| 4.75 | 99.6 |
| 2.36 | 95.1 |
| 1.18 | 73.1 |
| 0.6 | 50.1 |
| 0.3 | 12.6 |
| Pan | 0 |

#### *4.3.3. Marble waste*

**Table 4.3 Data obtained for marble waste**

| Sieve size (mm) | % Passing |
|---|---|
| 4.75 | 98.34 |
| 2.36 | 90.54 |
| 1.18 | 69.41 |
| 0.6 | 42.75 |
| 0.3 | 8.75 |
| Pan | 0 |

## 5.MIX DESIGN

#### *5.1 objective*

The objective of concrete mix design as follows;

1) The main objective is to achieve the minimum strength.

2) The second objective is to make the concrete in the most economical manner. Cost wise all concretes depends primarily on two factors, namely cost of material and cost of labor. Labor cost is same for form work,batching,mixing,transporting and curing of good concrete.

#### *5.2. procedure for mix design as per is: 10262-1982*

1) The following basic data are required for a concrete mix.

a. Characteristics compressive strength of concrete.

b. Degree of workability desired.

c. Maximum water cement ratio of coarse aggregrate.

d. Type of maximum size of coarse aggregrate.

e. Standard deviation based on concrete control.

f. Statistical constant accepted.

g. Grade of cement used.

2) Target mean strength is determined as

$$\mathbf{F_t = f_{ck} + k.s}$$

3) The water cement ratio for the target mean strength is obtained from fig2 of IS: 10262-1982 and is limited as per table 3 of IS:456-2000.

4) The air content is estimated as per table 3 of IS: 10262-1982.

5) Appropriate sand and water content per $m^3$ of concrete are selected as per table 4 and 5 differs in IS:456-2000.

6) Adjustment in sand percentage and water content are made as per table 6 if the condition given for table 4 or 5 differs in IS:456-2000.

7) Collected water quantity is computed and hence from W/C ratio.

8) The quantity of fine aggregrate and coarse aggregrate per unit volume of concrete can be calculated from the following equation.

**V = [W + C/Sc + ( 1/1-P * $C_a/S_{fa}$ )] * 1/1000**

The mix proprotions by weight are computed by keeping cement as one unit.

### *5.3. design stipulations*

Design stipulations for $M_{20}$ mix are tabulated in the table.

**Table 5.1 Design data**

| | |
|---|---|
| Characteristic compressive strength required in the field at 28 days | 20 N/mm2 |
| Maximum size of aggregate | 20mm |
| Degree of workability | 0.9 compaction factor |
| Degree of quality of control | Very good |
| Type of exposure | Mild |

### *5.4. concrete mix design ($m_{20}$)*

Grade of concrete = $M_{20}$
Cement = OPC Grade 53

### *5.5. target mean strength of concrete*

Target mean strength of concrete is given by the formula:

**$F_t = f_{ck} + k.s$**

For a tolerance factor of K = 1.65 and $f_Ck$ =20 N/mm$^2$ and standard deviation S = 4 the target mean strength for the specified characteristic cubic strength is

Target mean strength, $F_t = f_{ck}$ + (1.65 x S) = 20+ (1.65x4) = 26.6 N / mm$^2$. For 20 mm sized aggregate, Maximum Water content is l86 kg/ m$^3$ (From IS 456-2000, Table 5).

### *5.6. selection of water and sand content*

From table 4 of IS:456-1978 for 20mm nominal maximum size aggregate and sand conforming to Zone 11 ,water content per cubic meter of concrete = 186kg and percentage of sand in total aggregate by absolute volume = 35 %.

### *5.7. determination of cement content*

Cement content is adequate for Mild exposure condition, according to Appendix A of IS: 456-1978.

### *5.8. selection water cement ratio*

The free water cement ratio required for the target mean strength of 26.6 N/mm$^2$ is 0.45 as obtained from the graph showing the variation of compressive strength with varying water cement ratio as per code. This is lower than the maximum value of 0.60 prescribed for Mild exposure in Appendix A of IS: 456 - 1978.The nominal mix ratio for M20 Grade concrete is 1:1.5:3.

## 6.CONCLUSIONS

The following conclusions were made from this project which evaluated the feasibility of fine using marble waste as a partial substitute of fine aggregate for construction purposes.

- Replacement of fine aggregate with marble waste material provides required compressive strength values for replacement up to 25% which are within limit as per Indian Standards.
- When Government implements this project for temporary shelters for who those affected by Tsunami, Earthquake, etc .., this material can be used for economic feasibility.
- It was found out that the optimum percentage for replacement of marble powder with sand and it is almost 10% sand for both cubes and cylinders.
- The marble waste is freely available so it is cost effective in construction.
- The flexural strength of waste marble mix concrete increases with the increase of the waste marble ratio in these mixtures.
- Test results show that these industrial wastes are capable of improving concrete performance.
- Scarcity of fine aggregate can be reduced to a certain limit.
- Through this project , a new construction material is formed replacing sand by partially .

## REFERENCES

[1] 'Partial Replacement of Cement with Marble Dust Powder'- International Journal of Advanced Engineering Research & Studies(vol. 1,2012)- Prof.shirule and Rakesh D Gupta.

[2] 'The use of stone waste by replacing OPC cement' -International Journal of Latest Trends in Engineering & Technology(vol.2,2013)- Prof.Jayesh kumar and Ankit Nileshchandra.

[3] 'The Feasibility and Need of use of Waste Marble Powder in Concrete Production'- IOSR Journal of Mechanical and Civil Engineering Vol. 1/ Issue Ill/April-June, 2012- Prof. Veena G. Pathan and Prof. Md. Gulfam Pathan.

[4] 'The partial replacement of cement with marble dust powder'- International Journal of Advanced Engineering Research and Studies Vol. 1/ Issue Ill/April- June, 2012- Prof. P.A. Shirulea, Ataur Rahmanb, Rakesh D. Gupta.

[5] 'Influence of Marble powder/granules in Concrete mix'- International journal of civil and structural engineering Volume 1, No 4, 2011- Baboo Rai, Khan Naushad H, Abhishek Kr, Tabin Rushad S and Duggal S.K.

[6] 'Partial Replacement of Cement with Marble Dust Powder'-International Journal of Advanced Engineering Research & Studies (vol.1, 2012)- Prof.shirule and Rakesh D gupta.

[7] 'The use of stone waste by replacing OPC cement' -International Journal of Latest Trends in Engineering & Technology (vol.2, 2013)- Prof.Jayesh Kumar and Ankit Nileshchandra.

[8] 'Partial Replacement of Cement with Waste Glass Powder'-International Journal of Advanced Technology in Civil Engineering (vol.2, 2013)- Dhanaraj Mohan and Dr.Keshav.