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Replacement of Coarse Aggregate in Concrete from Waste Marble

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Abstract— Todaywe are faced with an important consumption and a growing need for aggregates because of the growth in industrial production, this situation has led to a fastdecreaseofavailableresources.Ontheotherhand,ahigh volume of marble production has generated a considerable amount of waste materials; almost 70% of this mineral gets wasted in the mining, processing and polishing stages which have a serious impact on the environment. The processing waste is dumped and threatening the aquifer. The main purposeofthisstudyistodemonstratethepossibilityofusing marblewastesasasubstituteratherthannaturalaggregatesin concrete production. This paper presents the study methodology, the characterization of waste marble aggregates and various practical formulations of concrete. This experimental investigation was carried out on two grades of concrete M20 This experimental investigation was carried out on the grades of concrete M20 substituting the coarse aggregate with waste marble chips The collected material was crushed by hammer crusher followed by jaw crusher followed by final screening. The final 20mm passing and 10 mm retaining material obtained were brought into grading zone confirming to IS 383-1970.Control mixes viz. M20 was designed as per IS10262-2009 for virgin aggregates. Cubes of sizes 150x150x150 mm.The samples were kept under water for the ages 3, 7 and 21 days. The Green concrete obtained was investigated for its suitability for structural concrete on the basis of different mechanical properties (compressive strength), workability (Slump value), The concrete formulations were produced with a constant water/cement ratio.

Keywords: marble waste, recycle waste, coarse aggregate, concrete, cement

I. INTRODUCTION

Marble ranks the largest produced natural stone in the world and it accounts for 50% of the world's natural stone production. Around 90% of the world's production ofmarble comes from India and approx 85% of India's production is received from Rajasthan and almost all mining and processingactivitiesareconcentratedaroundUdaipur,where the proposed study is planned to undertake. The marble mining industry has come up significantly in recent past. Rajasthan has around 4000 marble mines and about 1100 marble gang saws (processing plants). The industry involves Mines, Processing plants, Cutters for the production of tiles for walls and floors, articles, waste reproduction and other ancillary works. The marble mining and the industry as a wholeisdifferentfromotherindustrieswiththeveryfactthat, the marble is a "Dimensional Stone", which means the stone is sold by size not by weight. (In other words in sqm not by tonnes)

Sincethesellingpriceincreasesmanifoldswithsize, all the operations involving mining & processing are aimed to get slabs as big aspossible.

A. Waste Generation

The very fact of being dimensional stone marble has contributed to the development of grave environmental problems in the region due to waste generation at different stages of mining and processing operations. The technical, operationalandmanagementpracticesintheindustryareless developed and they have also contributed significantly to greater wastegeneration.

Finished marble produced (Saleable product)	30%
Mining waste (including small blocks of lower revenue, boulders, cutting slurry)	50%
Processing waste (including broken tiles, dressing waste, cutting slurry)	15%
Polishing and transportation Waste	05%
Total excavated marble	100%

Table 1: Marble Waste Production

It has become necessary to reuse these wastes particularly in the manufacture of concrete products for construction purposes. The main goal of this study is to demonstrate the possibility of using marble wastes as a substitute rather than natural aggregates in concrete production. Because of continual depletion of quarries aggregates, construction materials are more and more judged by their ecological characteristics.

II. LITERATUREREVIEW

A. HanifiBinici, Tahir Shah, OrhanAksogan, Hasan Kaplan; November 2008

They highlighted some technical aspects concerning the use of these waste materials in their Journal of Materials Processing Technology. Durability of concrete made with granite and marble as coarse aggregates was studied.

The influence of coarse and fine aggregates on the strength of the concrete was evaluated. Durability of the concrete made with marble and GBFS was found to be superior to the control concrete. In the specimens containing marble, granite and GBFS there was a much better bonding between the additives and the cement. Furthermore, it might be claimed that marble, granite and GBFS replacement providedagoodcondensedmatrix.Theseresultsillustratethe prospects of using these waste by-products in the concrete production.

B. H. Hebhoub,H. Aoun,M. Belachia,H. Houari,E.Ghorbe; March2011

They represent in their journal of Use of waste marble aggregates in concrete the study methodology, the characterization of waste marble aggregates and various practical formulations of concrete. This experimental investigation was carried out on three series of concrete mixtures: sand substitution mixture, gravel substitution mixture and a mixture of both aggregates (sand and gravel).

The concrete formulations were produced with a constant water/cement ratio.

C. (Vaidevi C; July2013)

In the study, the use of marble dust collected during the shapingprocessofmarbleblockshasbeeninvestigatedinthe concrete mixtures as cementitious material. The study showedthatmarblewastes,whichareinthedustform,could be used as cementitious material in concrete mixtures where they are available and the cost of construction is lower than ordinary concretematerials.

The concrete is prepared containing 5, 10, 15 and 20% waste of marble dust with cement compared to the total quantityofnormalconcrete.Thepreparedmixtureswerethen studied in terms of their properties both in fresh and in hardened state. In particular, tests were conducted and cured at different times to find compressive strength and tensile strength with and without partial replacement of marble dust incementconcreteandformortaralsodeterminedfor14and 28 days. Cost was analyzed for finalresult.

III. MATERIALUSED

A. Cement:

Portland Pozzolona cement of Jaypee conforming to IS 269-1989andIS4031-1968wasadoptedinthiswork.Thecement used is Portland Pozzolana Cement (PPC) is obtained by either intergrinding a pozzolanic material with clinker and gypsum or by blending ground pozzolana with ground cement.

B. Coarseaggregate:

Theaggregateusedinthisprojectmainlyofbasaltrockwhich comes under normal weight category. The aggregates are locallyavailable.50%oftheaggregateusedareof10-12mm size and remaining 50% are of 20mm size. The coarse aggregate was also tested for various properties like impact value test, crushing value test, water absorption, Specific gravity test to check their suitability for theexperiment.

C. FineAggregate:

Natural sand which is easily available and low in price was usedinthework.Ithascubicalorroundedshapewithsmooth surface texture. Being cubical rounded and smooth texture it givesgoodworkability.Sandwhichisusedhereistakenfrom Banas River. Particles of this sand have smooth texture and are blackish. Sieve analysis was done to find out fineness modulus which comes out to be 2.7 which is under limit as per IS 383-1970

D. Water:

Water used was free from injurious amount of oils, acid, alkalis, salt ,sugar and other deleterious substances. Water wasconfirmingasperIS:456andwasfitforconstructionuse.

E. Waste MarbleAggregate:

We will be using Waste marble in our project work.

Thisisthemarblewhichisusedintheconstructional purposes in our college. High amount of wastage of this is produced in our college itself. This is thrown away as a complete waste aftercutting.

Fig. 1: Marble whose waste product is being used in our study

IV. EXPERIMENTALWORK

The Experimental Program was carried out by testing the under mentioned properties of M20 concrete and M40 concrete mixes and they were put along the replacement mixesstartingfromtheStandardtothe50%replacementmix with the interval of 10% in each mix. The replacement was done partially replacing the Fine Aggregate with the Recycle Aggregate obtained from the Construction and Demolition Waste.

A. Workability

The Slump Test has been adopted for the experimental investigation on workability of the mix.The test is popular duetothesimplicityofapparatususedandsimpleprocedure. Unfortunately, the simplicity of the test often allows a wide variabilityinthemannerthatthetestisperformed.Theslump test is used to ensure uniformity for different batches of similar concrete under field conditions.

The slump test result is a measure of the behaviour of a compacted inverted cone of concrete under the action of gravity. It measures the consistency or the wetness of concrete.

The Dimensions of the cone used in the Slump Test hadthebasediameterof200mmandTopdiameteras100mm extending over the 300mm of the height of thecone.The test was conducted in accordance to IS 1169.

B. Compression Test

Out of many test applied to the concrete, this is the utmost important which gives an idea about all the characteristics of concrete.

The acceptance criteria of quality of concrete is laid downinIS:456-2000.Thecriterionismandatoryandvarious provisionsofthecodehavetobecompliedbeforethequality of concrete isaccepted.

In all the cases, the 28-days compressive strength shall alone be the criterion for acceptance or rejection of the concrete with the optional 7 day strength.

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Inthisstudytheconcretecubesaretestedfortheage of 7, 28, and 56 days with the help of 15x15x15 cm^3cubes.

These test were conducted in accordance to IS 516-1959 with formation of 3 cubes for each age of each replacement or standard mixes. These specimens are tested

by compression testing machine after 7 days, 28 days and 56 days of curing. Load should be applied gradually at the rate of140kg/cm2perminutetilltheSpecimensfails.Loadatthe failure divided by area of specimen gives the compressive strength ofconcrete.

C. Split Tensile StrengthTest

The Plain cement concrete is not remarkable for its tension bearingcapacity and therefore it is expected to range from 7–10% of Compressive Strength of the mix at respective age.

The Specimen to be used for the determination of Split Tensile Strength test according to IS 5816:1999 should behavingdiametergreaterthanfourtimesthemaximumsize of coarse aggregates or 150mm whichever is greater.

A splitting tension test uses a standard 150 mm diameter, 300 mm long (6-inch diameter, 12" long) test cylinderlaidonitsside.Adiametriccompressiveloadisthen applied along the length of the cylinder until itfails.

The magnitude of tensile stress developed due to application of vertical load is given by

$$S= 2P/\pi dl$$

Where

P is vertical load applied in KN
d is diameter of the specimen

l is length of the specimen

So, for each batch of standard or replacement mixes Threemoulds of 150 x 300 mm3 cylinder were casted.

The principle of Split Tensile Strength test is failure of concrete is due to horizontal tension and not vertical compression.

1) Sorptivity:

The durability of concrete largely depends on the ease with whichfluidsenterandmovethroughthematrix.Forexample, deterioration due to chloride ions from de-icing salts or seawateriscausedbythetransportofachloridesolutioninto thematerial.Although,ingeneral,permeabilityistakenasan indicator of a concrete's ability to transport water (or oxygen and carbon dioxide), more precisely there are two mechanisms controlling the uptake and transport of water. Permeability, which is a measure of the flow of water under pressure in a saturated porous medium, and sorptivity,which characterises the material's ability to absorb and transmit water through it by capillary suction. Whilst permeability is an important parameter for water retaining structures, amore important parameter (which is directly related to durability) for above ground structures is sorptivity

2) WaterAbsorption:

The durability of concrete near an exposed surface is largely determined by the rate at which harmful agents canpenetrate into the concrete. This test presents a simple analysis of the penetration of' water into unsaturated concrete and describes a method by which the material constant that determines the rate of penetration, the sportively, can be measured, together with the effectiveporosity.

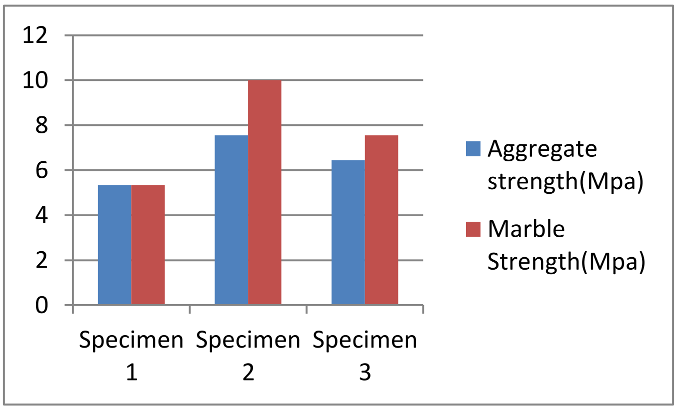
V. Test Results and Discussion

A. TestResults

1) Compressive Strength of Concrete: 3 Days Strength of Concrete

S. N o.	Specimen Name	Grade of Concrete	Cube Size (mm$^{3)}$	Area (mm^2)	Load (KN)	Strength (N/mm^2)
1	3M	M20	150x150x150	22500	120	5.33
2	3A	M20	150x150x150	22500	120	5.33
3	3M	M20	150x150x150	22500	225	10
4	3A	M20	150x150x150	22500	170	7.55
5	3M	M20	150x150x150	22500	170	7.55
6	3A	M20	150x150x150	22500	145	10

Table 2: 3 Days Strength of Concrete



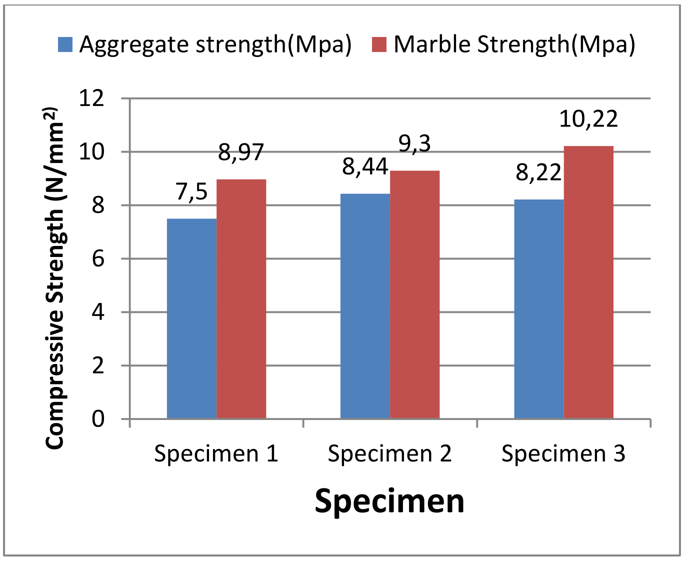
X axis: Samples; Y axis: Compressive Strength (Mpa)
Fig. 2: 3 Days Strength of Concrete

2) Compressive Strength of Concrete: 7 days Strength of Concrete

S.N o.	Specimen Name	Grade of Concrete	Cube Size(mm$^{3)}$	Area (mm$^{2)}$	Load (KN)	Strength (N/mm$^{2)}$
1	7M	M20	150x150x150	22500	170	7.5
2	7A	M20	150x150x150	22500	190	8.44
3	7M	M20	150x150x150	22500	185	8.22
4	7A	M20	150x150x150	22500	202	8.97

5	7M	M20	150x150x150	22500	210	9.3
6	7A	M20	150x150x150	22500	230	10.22

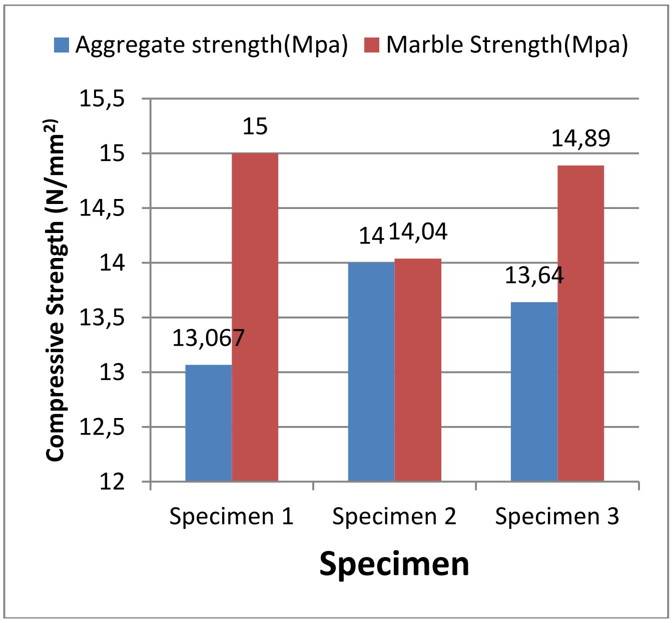
Table 3: 7 Days Strength of Concrete



X axis: Samples; Y axis: Compressive Strength (Mpa)

3) *Compressive Strength of Concrete: 21 Days Strength of Concrete*

S.No.	Specimen Name	Grade of Concrete	Cube Size(mm³)	Area (mm²)	Load (KN)	Strength (N/mm²)
1	21M	M20	150x150x150	22500	294	13.067
2	21A	M20	150x150x150	22500	315	14
3	21M	M20	150x150x150	22500	307	13.64
4	21A	M20	150x150x150	22500	340	15
5	21M	M20	150x150x150	22500	316	14.04
6	21A	M20	150x150x150	22500	335	14.89



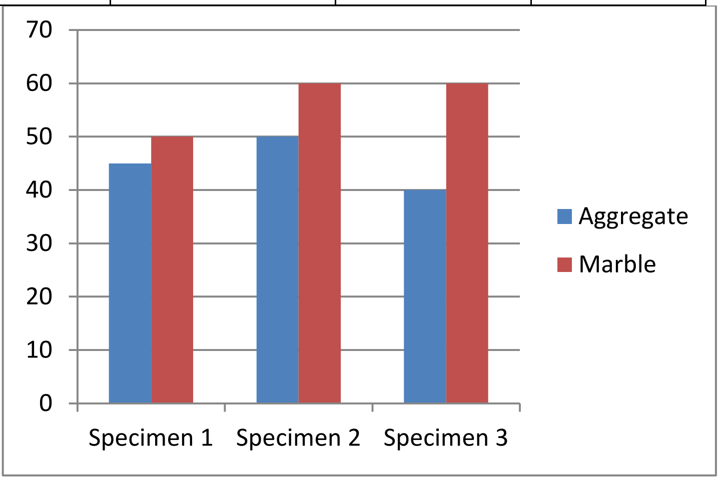
X axis: Samples; Y axis: Compressive Strength (Mpa)

Marble Blocks

Aggregate Blocks

A. Workability

S.No.	Specimen Name	Grade of Concrete	Slump Value (mm)
1	Specimen 1A	M20	45
2	Specimen 1M	M20	50
3	Specimen 2A	M20	50
4	Specimen 2M	M20	60
5	Specimen 3A	M20	40
6	Specimen 3M	M20	60



X axis : Specimen Name ; Y axis: Slump Value

ForMarble:

- The impact and crushing values of waste marble chips were found to be lesser than that of the standard virgin aggregate.
- Theresultsobtainedshowthatmarblechipsexhibitmore strengthandareharderthanthestandardstoneaggregate.
- The specific gravity of marble was found out to be slightly higher than that of standardaggregate.
- Water absorption of marble chips came out to be much lesser than standard stoneaggregate

A. ForConcrete:

1) Compressive Strength:

- The compressive strength of marble aggregate is higher than the standardaggregate.
- This happens when the standard stone aggregate is completely replaced by marble aggregate i.e. 100% replaced.
- This behavior is seen in M20 grade ofconcrete.
- Theprobablereasonforthismaybethelowerimpactand crushing values of marble aggregate than standard stone aggregate.

I. CONCLUSIONS

It was found outthat:

- Concrete replaced with marble aggregate showed a lot improved workability because of less water absorption andrelativelysmoothersurfacesthannaturalaggregates.
- Compressive strength also increased and themaximum C.S. was found out at 80% replacement of natural aggregate with marble for both M20 and M40.
- Tensile strength increased and the maximum was obtained at 80% replacement in M20 and 60% replacement inM40.
- Rapidchloridepenetrationtestyieldedverylowchloride permeability which was 667 coulombs for 60% replacement.
- The sorptivity and water absorption tests also yielded better results for replacements of standard stone aggregate with waste marbleaggregate.

Hence it can be concluded from these results that:

- Marble can be used as a good replacement material for coarse naturalaggregates
- It shows comparative or enhanced results than coarse aggregate inconcrete.
- The optimum amount combining all the factors of compressive, tensile strengths, workability and durability can be 80% of marble as a replacement of coarse aggregate for M20grade.
- The optimum amount combining all the factors of compressive, tensile strengths, workability and durability can be 60%-80% of marble as a replacement of coarse aggregate for M40grade.
- But the study has to be supplemented with the study of other durability properties aswell.

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