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OPTIMUM REPLACEMENT OF MARBLE CHIPS AND MARBLE DUST AS AGGREGATES IN M20 CONCRETE

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Abstract – Today we 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 fast decrease of available resources. On the other hand, a high 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. Therefore, 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. The paper presents 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: Fine aggregate substitution mixture and course aggregate substitution mixture .The concrete formulations were produced with a constant water/cement ratio.

I. INTRODUCTION

Green concrete is a concept of using eco-friendly materials in concrete, to make the system more sustainable. Green concrete is very often and also cheap to produce, because for example, waste products are used as a partial substitute for aggregates, charges for the disposal of waste are avoided, energy consumption in production is lower, and durability is greater. This concrete should not be confused with its color. Waste can be used to produce new products or can be used as admixtures so that natural resources are limited and used more efficiently and the environment is protected from waste deposits. Inorganic residual products like stone dust, crushed marble waste are used as green aggregates in concrete. This project summarizes the various efforts underway to improve the environmental friendliness of concrete to make it suitable as a "Green Building" material.

II. OBJECTIVES OF THE STUDY

The key objective of this work was to develop concrete mixtures, using marble waste as a partial replacement for normal granitic aggregates and fine aggregates, which exhibit acceptable properties comparable to that of structural coarse aggregates and fine aggregates.

- To study the effect of use of waste marble dust on the mechanical properties of concrete.
- To study the effect of use of waste marble aggregates on the mechanical properties of concrete.
- To compare the compressive strength using marble products with the given design mix.
- To establish alternative for sand and course aggregate with partial use of marble wastes in concrete.

Research Hypothisis

Marble chips may be suitably used as an alternative (partial replacement) to normal granitic aggregates in structural concrete and Marble dust powder may be suitably used as an alternative (partial replacement) to normal fine aggregates in structural concrete.

Scope of the Study

In concrete mix design, it is necessary to analyse experimentally and practically all the components of the concrete mix i.e. Cement, aggregates, additives and water. Due to the limited time available, it wasn‟t possible to investigate the properties of the above mentioned components. Long term behaviour study of marble aggregate concrete use in reinforced concrete under weather exposure was also not possible due to time constraints. In this project, 43 grade OPC was used assuming its properties hold for other types of cement. The research will be majorly dealing with the analysis of the properties of marble waste chips and marble dusts to be used as coarse aggregates and fine aggregates in concrete. Prior to developing mix designs, grading was done to obtain the required particle size
distribution and tests were performed to characterise the aggregate. The compressive strengths at 14 and 28 days of curing of concrete cubes will be analysed. For CA replacement six trial mixes were prepared, namely;

- Normal mix (control) i.e. cement + water + FA + coarse aggregate (granitic).
- Special mix 1 i.e. cement + water + FA+ blended
- coarse aggregate (5% marble waste chips + 95% normal CA)
- Special mix 2 i.e. cement + water + FA + blended
- coarse aggregate (10% marble waste chips + 90% normal CA)
- Special mix 3 i.e. cement + water + FA + blended
- coarse aggregate (15% marble waste chips + 85% normal CA)
- Special mix 4 i.e. cement + water + FA + blended
- coarse aggregate (20% marble waste chips + 80% normal CA)
- Special mix 5 i.e. cement + water + FA + blended
- coarse aggregate (50% marble waste chips + 50% normal CA)

Similarly for fine aggregate replacement five trial mixes were prepared, namely;

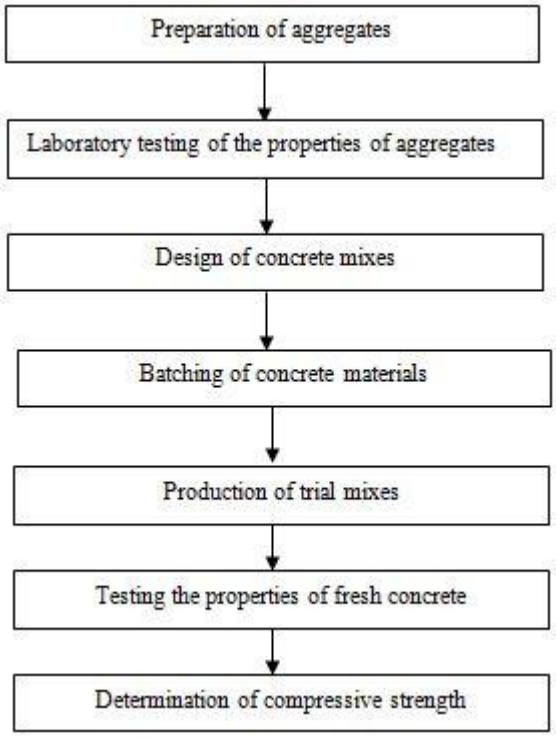
- Special mix 1 i.e. cement + water + CA + blended fine aggregate (5% marble dust + 95% normal FA)
- Special mix 2 i.e. cement + water + CA+ blended fine
- aggregate (10% marble dust + 90% normal FA)
- Special mix 3 i.e. cement + water + CA + blended fine aggregate (15% marble dust + 85% normal FA)
- Special mix 4 i.e. cement + water + CA + blended fine aggregate (20% marble dust + 80% normal FA)
- Special mix 5 i.e. cement + water + CA + blended fine aggregate (50% marble dust + 50% normal FA)

III. LITERATURE REVIEW

Nutan Patel et al. studied on Marble Waste: Opportunities for Development of Low Cost Concrete. The author studied Based on the Indian Standard (IS: 10262-1982), design mix for M30 grade of concrete was prepared by partially replacing fine aggregate with five different percentages by weight of marble powder (0%, 5%, 10%, 15%, and 20%).There is a slight decrease in compressive strength value concrete mix when 20% marble powder is used as compared with that of 15% marble powder mix. Compressive strength of the concrete has increased with increasing percentages of marble dust additions. The author conclusion for this research rate of the 0% marble waste 28 days strength is 38 N/mm2 at this strength of concrete rate is Rs. 3760.25. After adding the marble dust increases the strength. The highest compressive strength has been demonstrated by 15% marble dust is 40.5 N/mm2 at this strength of concrete rate is Rs. 3732.56. By using the marble dust the rate of the concrete is decrease and strength is increase. Shirule, P.A et al .investigated Partial replacement of cement with marble dust powderin this paper author studies 30 cubes and 30 cylinders have been casted. The compressive strength and split tensile strength of cubes and cylinders was measured for 7 and 28 days and cement used is 53 grade. M20 grade with nominal mix 1:1.5:3 as per IS 456-2000 was used and a water cement ratio of 0.5. Marble powder were added in concrete in step of 5% (0%, 5%, 10%, 15%, 20%).this paper concluded by the author strength of concrete has been tested on cylinder at 7 days curing and 28 days. 7days test has been conducted to check the gain in initial strength of concrete. 28 days test gives the data of final strength of concrete at 28 days curing. At 10% use of marble waste in concrete there is 27.4% increase in initial compressive strength. Up to 10% replacement of marble waste there is increase of compressive strength and split tensile strength. Ali A. Aliabdo et al.:studied on the Re-use of waste marble dust in the production of cement and concrete. The author study in paper the properties of concrete contained marble dust as a cement replacement and as a sand replacement. The replacement ratios which have been studied were 0.0%, 5.0%, 7.5%, 10.0% and 15% by weight. Water to powder ratio (w/p) or water to cement ratio (w/c) were 0.50 and 0.40 in case of cement replacement and in case of sand replacement respectively. This paper concluded by in concrete compressive strength increases with the increase of marble dust ratio as sand replacement up to 15.0% of sand by weight. 0.4 w/c ratio use of replacement marble dust in cement content of slightly increase comp. strength.0.4 w/c ratio use of replacement of marble dust in cement content for 10% in maximum split tensile strength and 0.5 w/c ratio in7.5% replacement marble dust for maximumsplit tensile strength Maximum bond strength of steel –concrete recorded with 10% replacement of marble dust in cement or sand both w/c condition.

IV. METHODOLOGY

Methodology flowchart for determining optimum Contents of theM_{20} concrete.



Batching of concrete materials by weight may be expressed as follows;

Wt. (C) + Wt. (CA) + Wt. (FA) + Wt. (Air) = Wt. (CC)

Where,

Wt (C) = Weight of cement
Wt (CA) = Weight of coarse aggregate
Wt (FA) = Weight of fine aggregate
Wt (Air) = Weight of entrained air
Wt (CC) = Weight of compacted concrete

Trial Mix

As per the mix design, the concrete is mixed and the slump test is conducted. But for the first mix we could not get the desired slump, i.e.75mm. So we redesigned the mix by keeping the water cement ratio constant and by increasing the water content by 3% the mix is redesigned. The mix did not give the desired slump. The procedure is continued till the desired slump is obtained. A water content of 9% gave the required slump. Therefore, the total quantity of materials required for 1m3 of concrete:

Materials	Quantity in kg/m^3
Cement	380

Fine Aggregate	693
Course Aggregate	1104
Water	209

Fixing the desired mix proportion and casting the specimens

M20 concrete mix proportioning experiments conducted following the IS code yielded a mix proportion of 1:1.72:2.85 for cement, sand and coarse aggregates with a W/C ratio of 0.55. Six different mixes namely MC-5, MC-10, MC-15, MC-20, MC-50, were prepared using Marble chip as a coarse aggregate replacement material. The specimen number represents the marble chip replacement level of coarse aggregate. Eighteen cube specimens including 3 nominal mixes of 150 x 150 x 150 mm were cast.

Likewise, the same procedure has been done for the fine aggregate replacement in the M20 concrete. M20 concrete mix proportioning experiments conducted following the IS code yielded a mix proportion of 1:1.72:2.85 for cement, sand and coarse aggregates with a W/C ratio of 0.55. Six different mixes namely MD-5, MD-10, MD-15, MD-20, MD-50, were prepared using Marble dust as a fine aggregate replacement material. The specimen number represents the marble dust replacement level of coarse aggregate. Fifteen cube specimens of 150 x 150 x 150 mm were cast.

Mix	Water kg/m^3	Cement kg/m^3	MC kg/m^3	F.A Kg/m^3	C.A Kg/m^3
Reference	209	380	_	693	1104
MC-5	209	380	55.2	693	1048.8
MC-10	209	380	110.4	693	993.6
MC-15	209	380	165.6	693	938.4
MC-20	209	380	220.8	693	883.2
MC-50	209	380	552	693	552

Mix	Water kg/m^3	Cement kg/m^3	MC kg/m^3	F.A Kg/m^3	C.A Kg/m^3
Reference	209	380	_	693	1104
MD-5	209	380	34.65	658.35	1104
MD-10	209	380	69.3	623.7	1104
MD-15	209	380	103.95	589.05	1104
MD-20	209	380	138.6	554.4	1104
MD-50	209	380	346.5	346.5	1104

V. DATA COLLECTION AND ANALYSIS

Inorder to determine the aggregate properties, we conducted the following tests on both marble aggregates of nominal size 20mm and marble dust :

- Sieve analysis test
- Specific gravity analysis test
- Aggregate crushing value
- LOS Angeles abrasion test
- Impact test
- Water absorption test

Similarly, in order to determine the workability of concrete we conducted the following test

- Slump test

Similarly, in order to determine the strength of concrete we conducted the following test

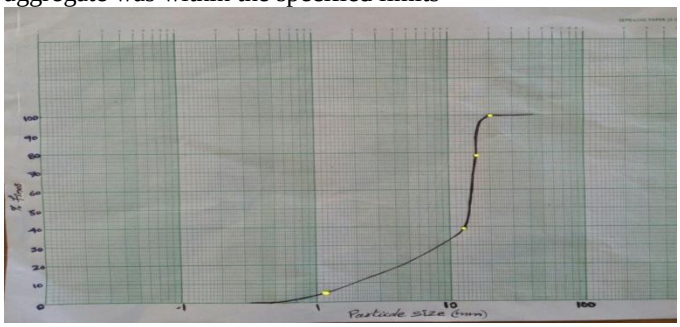
- Compression test

Laboratory test results

Sieve analysis test

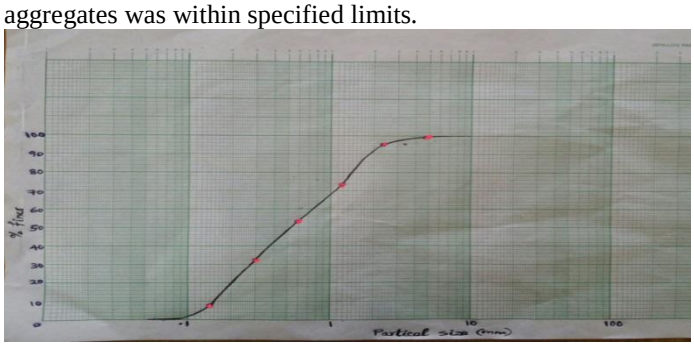
IS Sieve No.	Particle Size'D (mm)	Mass of CA retained	%Mass retained	Cumulative % retained	%Finer
20	20	0	0	0	100
16	16	423	21.15	21.5	78.5
12.5	12.5	786	39.3	60.45	39.55
10	10	700	35	95.45	4.55
4.5	4.5	91	4.55	100	0
Pan		0	0	100	

Mass of dry sample was 2000g. The grading of the normal aggregate was within the specified limits



IS Sieve No.	Particle Size D (mm)	Mass of CA retained	% Mass retained	Cumulative % retained	% Finer
4.75	4.75	3	0.15	0.15	99.85
2.36	2.36	80	4	4.15	95.85
1.18	1.18	453	22.65	26.8	73.2
600	.600	410	20.5	47.3	52.7
300	.300	412	20.6	67.9	32.1
150	0.150	486	24.3	92.2	7.8
Pan		156	7.8	100	0

Mass of dry sample was 2000g. The grading of the fine aggregates was within specified limits.



Results of tests on Aggregates

Test	Sample 1(%)	Sample 2(%)	Average(%)
ACV NA	30.3	29.7	30

ACV-MA	26.51	27.17	26.84
LA Abrasion Test-NA	52.91	52.67	52.8
LA Abrasion Test-MA	36.72	36.28	36.5
AIV Test NA	31.2	28.8	30
AIV Test MA	57.96	57.07	57.515

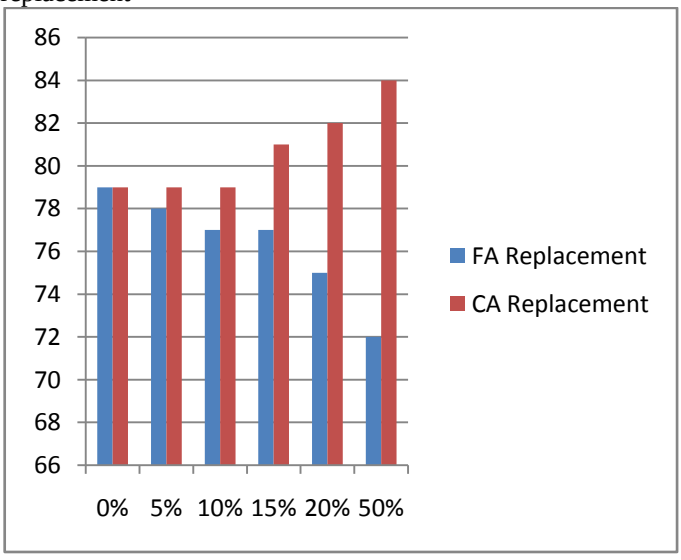
Type of aggregate	Specific gravity	Water absorption (%)
Normal coarse aggregate	2.67	0.5
Marble chips	2.99	_
Normal fine aggregate	2.57	3
Marble dust	2.3	_

Slump test

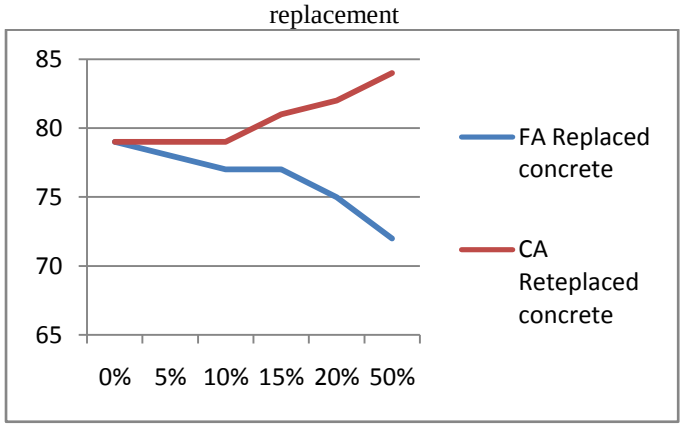
In order todetermine the workability of concrete that has been prepared using the obtained mix design, we conducted the slump tests for each percentage of FA and CA replacements in the concrete.

Type of mix	Slump in mm (FA replacement)	Slump in mm (CAreplacement)
Normal mix(Control mix)	79	79
Special mix 1 (5% replacement)	78	79
Special mix 2 (10% replacement	77	79
Special mix 3 (15% replacement	77	81
Special mix 4 (20% replacement	75	82
Special mix 5 (50% replacement	72	84

slump (mm) obtained with each level of aggregate replacement



variation in slump (mm) with each level of aggregate replacement



From the experimental data it is clear that the slump obtained by the replacement of Coarse aggregate is increased with the increase of percentage of replacement. But the slump obtained by the replacement of fine aggregate decreases with the increase of percentage of replacement of FA. This decreasing tendency of slump may be due to the high cohesiveness of mix which is obtained by the addition of marble dust. The marble dust is finer than the fine sand. This marble dust can act as filler material, which fills the voids in the concrete mix.

Terms and Abbreviations Used in Study

MA-Marble Aggregate
NA-Normal Aggregate
ACV-Aggregate Crushing Value
LA Abrasion-Los Angeles Abrasion

Compressive strength

In order to find the variations in the strength of concrete containing marble dust and marble chip as FA and CA, three control mix cubes are casted, which contains normal course aggregates and river sand as CA and FA. A number of concrete test specimens are also casted with varying FA and CA .The compressive strength of various concrete specimen with varying FA and CA content are given in the table.

The compressive strength of various concrete specimens with varying FA and CA are given in the table below.

Type of mix With Replacement Level %	Characteristic compressive strength (N/mm2)	Age of curing days	Average compressive strength (N/mm2)	
			Specimens with varying CA contents	Specimens with varying FA contents
Normal mix (Control)	20	28	26.58	26.58
Mix 1 5%	20	28	26.54	26.59
Mix 2 10%	20	28	23.07	26.64

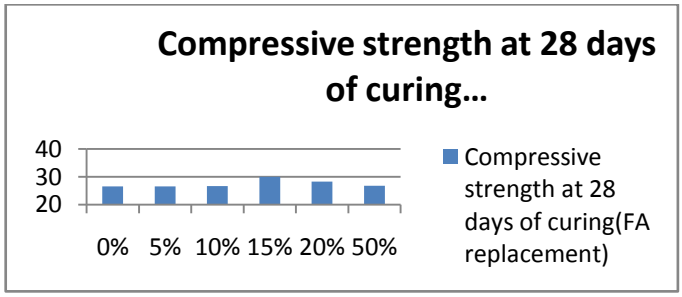
Mix 3 15%	20	28	25.41	30.01
Mix 4 20%	20	28	23.67	28.31
Mix 5 50%	20	28	29.85	26.79

VI. RESULTS AND DISCUSSION

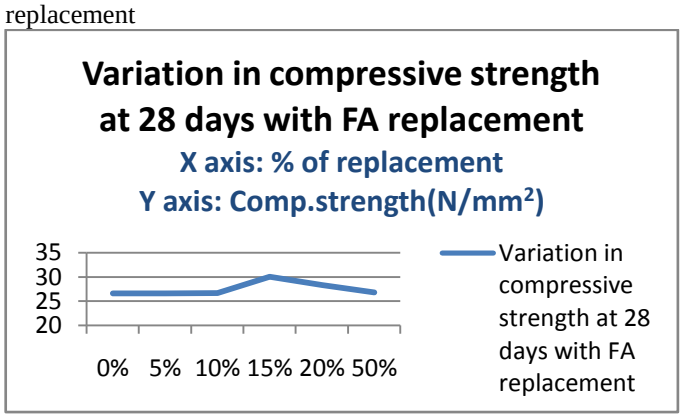
Compressive strength

Fine aggregate replacement

The 150 mm size concrete cubes were used as test specimens to determine the compressive strength. The results of standard cubes are compiled in Table 16. The Indian standard method resulted in highly conservative results of compressive strength for the M20 grade concrete. Compressive strength was obtained as per IS: 516-1959.The 28 days compressive strength of green concrete is 12.9% higher than the control mix.



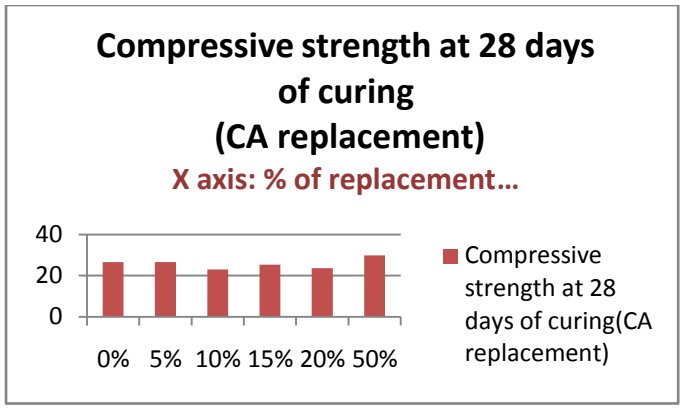
Variation in compressive strength at 28 days with FA replacement

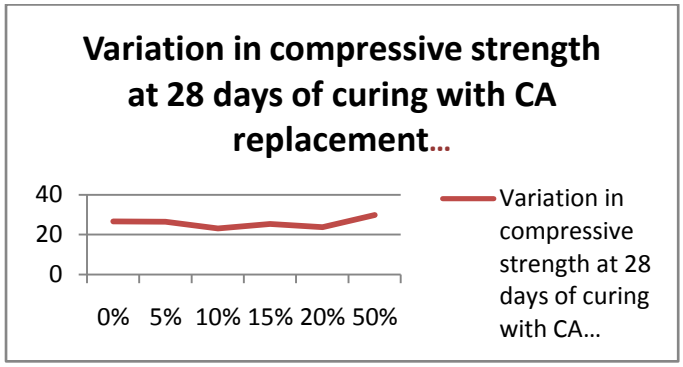


Above graphs shows the compressive strength of concrete containing marble dust. The strength increased with the increasing replacement of fine aggregate up to 15%. The specimen with 50% marble dust showed 12.9% more compressive strength than the reference mix at 28-days.

Coarse aggregate replacement

The 150 mm size concrete cubes were used as test specimens to determine the compressive strength. The results of standard cubes are compiled in Tables-7. The Indian standard method resulted in highly conservative results of compressive strength for the M_{20} grade concrete. Compressive strength was obtained as per IS: 516-1959.The 28 days compressive strength of green concrete is 12.30% higher than the control mix.





The above graphs shows the compressive strength of concrete containing marble chips. The strength increased with the increasing replacement of coarse aggregate up to 50%. The specimen with 50% marble chips showed 12.30% more compressive strength than the reference mix at 28-days.

VII. CONCULUSION

All the experimental data shows that the addition of the marble wastes improves the physical and mechanical properties. These results are of great importance because this kind of innovative concrete requires large amounts of fine particles. Due to its high fineness of the marble dust it provided to be very effective in assuring very good cohesiveness of concrete. From the above study, it is concluded that the marble dust may be used as a replacement material for fine aggregate.

- Compressive strength of the concrete has increased with increasing percentages of marble dust additions. The highest compressive strength has been demonstrated by MD-15 specimen.
- The chemical compositions of marble sludge powder such as, MgO, Na_2O K_2O, MnO, Fe_2O_3 ,Al_2O_3, CaO, and SiO_2 are comparable with that of cement.
- The replacement of coarse aggregate with 50% marble chips (Green concrete) gives an excellent result in strength aspect and quality aspect. The results showed that the MC-50 mix induced higher compressive strength. Increase in the marble chip content improves the workability.

This report clearly indicates an increasing trend and

incentives for the greater use of manufactured and recycled marble aggregates in construction. There are, however limitations to the use such materials. Use of such concrete products in future will not only have an environmental impact but also facilitate economy.

RECOMMONDATION

From the laboratory test results and study, we would like to recommend the use of marble aggregates in the production of concrete with medium to high compressive strengths especially for low cost construction. One of the key objectives of the project is to provide cheaper building materials. The use of marble aggregates in concrete production would significantly lessen the high cost of concrete because these aggregates can be gotten as a waste from marble products manufacturing industries. These aggregates would also provide haul cost savings since they are lighter than the normal aggregates.

The recycling and use of the aggregates will reduce environmental degradation in two aspects:

- Reduction of overdependence on natural sources of aggregates i.e. granitic aggregates. This will reduce quarrying for normal aggregates.
- The marble waste products can be put into a more beneficial use as aggregates in concrete, other than dumping and land filling.

Hence, the use of these aggregates will endorse environmental sustainability and sustainable development.

We would like to recommend further research on the behaviourof marble aggregates in reinforced concrete i.e. its suitability in RC beams etc. and also in the use in pre-cast elements. Further investigation should be done on the long term behaviour of marble aggregate concrete under moderate weather exposure that is external exposure.

REFERENCES

[1] Patel N.“Marble Waste: Opportunities For Development of Low Cost Concrete” Global research analysis ,Journal of construction and building material ,Volume : 2 | Issue : 2 ,Feb 2013 ,ISSN No 2277 – 8160

[2] Shirule ,P.A “ partial replacement of cement with marble dust powder” International Journal of Advanced Engineering Research and Studies E-ISSN2249–8974

[3] Ali A. Aliabdo “Re-use of waste marble dust in the production of cement and concrete” construction and building material 50(2014)28-41 September 2013

[4] KursatEsatAlyamaç et al. “A preliminary concrete mix design for SCC with marble powders” Construction and Building Materials 23 (2009) 1201–1210

[5] [5] BouzianiTayeb“ Effect of Marble Powder on the Properties of Self-Compacting Sand Concrete” The Open Construction and Building Technology Journal, 2011, 5, 25-29

[6] Shelke, V.M “Effect of marble powder with and without silica fume on mechanical properties of concrete” IOSR Journal of Mechanical and Civil Engineering (IOSRJMCE)ISSN : 2278-1684 Volume 1, Issue 1 (May-June 2012), PP 40-45

[7] Noha M. Solimana “Effect of using Marble Powder in Concrete Mixes on the Behavior and Strength of R.C. Slabs” International Journal of Current Engineering and Technology ISSN 2277 - 4106 December 2013

[8] Hassan A. Mohamadien“ The Effect of marble powder and silica fume as partial replacement for cement on mortar” Interional journal of civil and structural engineering Volume 3, No 2, 2012

[9] Godwin A. Akeke, Maurice E. Ephraim et AL. “structural properties OF rice husk ash concrete.” International Journal of Engineering and Applied Sciences may 2013. Vol. 3, No. 3 , ISSN2305-8269

[10] Shazim Ali Memon et al “Production of Low Cost Self Compacting Concrete Using Rice Husk Ash” Advancing and Integrating Construction Education, Research & Practice August 4-5, 2008, Karachi,, Pakistan First International Conference on Construction In Developing Countries .

