The Study of role of Partial Replacement of Cement with Marble Powders

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Abstract— The aim of this current study is both to avoid the environmental. In this way, we will help to protect the environment by consuming the waste marble dust obtained as a by- product of marble sawing and shaping processes in the factories those operating in our region. Stone industry is an important factor in worldwide economy. Despite this, a large amount of residues is produced in ornamental stone industry with different dimension and particle size. The increasing rate at which raw material are continuously transformed into industrial products results in waste generation. Consequently, recycling of industrial wastes and byproducts is becoming a crucial demand by the environmental laws in agreement with the concept of sustainable development. The present study was therefore planned to explore the possibility of usage of waste marble powder (WMP) as partial replacement of sand for production of concrete.The main purpose of this research is to investigate the possibility of utilizing waste marble dust generated during cutting and polishing process in marble factories in order to reuse it in cement and concrete production. Physical and mechanical properties of paste, hardened mortar and hardened concrete made of marble dust modified cement were investigated. The effect of marble dust addition on the internal microstructure and hydration products of paste samples were also investigated. Testing specimens were prepared by blending marble dust with cement and sand in 0.0%, 5.0%, 7.5%, 12.5%, 17.5 and 22.5% replacement ratios by weight [6].

Key Words : Partial Replacement, Marble Powders, Flexural Strength, Compressive Strength
Sub Area : Construction Technology & Management
Broad Area :Civil Engineering

I. INTRODUCTION

The advancement of concrete technology can reduce the consumption of natural resources and energy sources which in turn further lessen the burden of pollutants on the environment. Presently, large amount of marble dust are generated in natural stone processing plants with an important impact on the environment and humans. In India, marble dust is settled by sedimentation and then dumped away which results n environmental pollution, in addition to forming dust in summer and threatening both agriculture and public health [1]. Thus the utilization of the marble dust in various industrial sectors especially the construction, agriculture, glass and paper industries would help to protect the environment. Waste can be used to produce new products or can be used as admixtures so that natural resources are used more efficiently and the environment is protected from waste deposits.Test results show that this industrial bi product is capable of improving hardened concrete performance up to 10%, Enhancing fresh concrete behaviour. 30 cubes, 15 Beam and 15 cylinders have been casted. The compressive strength, Flexural strength and tensile strength of cubes and cylinders was measured for 7 and 28 days [1]. There are several reuse and recycling solutions for this industrial by-product, both at an experimental phase and in practical applications. On the other hand, recycling waste without properly based scientific research and development can result in environmental problems greater than the waste itself. One of the logical means for reduction of the waste marble masses calls for utilizing them in building industry itself. Some attempts have been made to find and assess the possibilities of using waste marble powder in mortars and concretes and results about strength and workability were compared with control samples of conventional cements and mortar/concrete . Marble powder is not available in all the places. Despite this fact, concrete production is one of the concerns worldwide that impact the environment with major impact being global warming due to CO2 emission during production of cement. In addition to this, due to fineness of the marble powder, it will easily mix with aggregates so that perfect bonding is possible [8]. Marble powder will fill the voids present in concrete and will give sufficient compressive strength when compared with the ordinary concrete. India is among the top world exporters of marble stone. The Indian marble industry has been growing steadily at an annual rate of around 10% per year. Cutting of stones produces heat, slurry, rock fragments and dust. 20 to 30% of marble blocks are converted in to powder. 3,172 thousand tons of marble dust was produced in year 2009-10. Waste Marble dust (WMD) can be used to improve the mechanical and physical properties of the conventional concrete. The possibility of utilizing WMD as an alternative very fine aggregate in the production of concrete will also induce a relief on waste disposal issues. Now-a-days the cost of material is increasing so if we use the waste material in the production of the concrete so we decrease the price [7]. In India, million tons of wastes from marble industries are being released from marble cutting, polishing, processing and grinding. If the waste is disposed on soils, the porosity and permeability of topsoil will be reduced, the fine marble dust reduces the fertility of the soil by increasing its alkalinity. When the waste is dumped and dried out, the fine marble dust suspends in the air and slowly spread out through wind to the nearby area. When dumped along a

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catchment area of natural rainwater, it results in contamination of over ground water reservoir and also cause drainage problem. Exposing the waste material to the environment directly can cause environmental problems. Therefore, many countries have still been working on how to re-use the waste materials [7].

II. EFFECTS OF MARBLE DUST AS PARTIAL REPLACEMENT OF CEMENT IN CONCRETE

The advancement of concrete technology can reduce the consumption of natural resources and energy sources and lessen the burden of pollutants on the environment. The cost of natural resources is also increased. They have forced to focus on recovery, reuse of natural resources and find other alternatives. Presently large amounts of Stone waste are generated in natural stone processing plants with an important impact on environment and humans [20]. The use of the replacement materials offer cost reduction, energy savings, arguably superior products, and fewer hazards in the environment. Stone blocks are cut into smaller blocks in order to give them the desired shape and size. During the process of cutting, in that original Stone mass is lost by 25% in the form of dust. Every year 250-400 tons of Stone wastes are generated on site. The Stone cutting plants are dumping the powder in any nearby pit or vacant spaces, near their unit although notified areas have been marked for dumping. This leads to serious environmental and dust pollution and occupation of a vast area of land, especially after the powder dries up so it is necessary to dispose the Stone waste quickly and use in the construction industry [20]. In INDIA, the marble and granite stone processing is one of the most thriving industry the effects if varying marble dust contents on the physical and mechanical properties of fresh and hardened concrete have been investigated This project describes the feasibility of using the marble sludge dust in concrete production as partial replacement of cement The compressive strength of concrete was measured f or 7 and 28 days. In order to evaluate the effects of marble dust on mechanical behavior, many different mortar mixes were tested [3].

III. METHODOLOGY

In order to achieve the objectives of the research and for the development of concepts, which are fundamental for the formation of the whole research work, a comprehensive literature review is made to understand the previous efforts which include the review of text books, periodicals and academic journals, seminars and research papers. The method followed to achieve the objectives of the research determines the required data, which intern is a ground to decide on type and method of data collection and their analysis. Different alternative data collection methods such as experiments, observations and archival records are examined and used when proved suitable. Both primary data (collected personally) from the source itself and secondary data from different sources is collected and used for the analysis.

The test results were presented in tabular and graphical forms and the analysis and discussions were also made on the research findings both qualitatively and quantitatively. Finally based on the findings, conclusions and recommendations were forwarded.

EXPERIMENTAL PROGRAMME

The following basic data required to be specified for a design of concrete mix

I. CHARACTERISTICS STRENGTH OF CONCRETE AT 28 DAYS (F_{CK}) = 20N/MM^2

II. MAXIMUM SIZE OF CRUSHED AGGREGATE = 20MM

III. DEGREE OF WORKABILITY (COMPACTING FACTOR) = 0.90

IV. VALUE OF STATISTICAL COEFFICIENT (K) = 1.65 (REFER IS: 456-2000 CLAUSE 9.2.2)

V. VALUE OF STANDARD DEVIATION (S) = 4.00 (REFER IS: 456-2000 TABLE 8)

Selection of water content and fine aggregate to total aggregate ratio:-

For maximum size of coarse aggregate 20 mm and based upon following parameters water content and fine aggregate to total aggregate ratio was selected from Table 4 given in IS: 10262.

- Design mix M25 grade
- Sand zone II
- Workability =0.90 CF
- Water/ Cement ratio= 0.43

Sand content as % of total aggregate by absolute volume=37%

Water content = 186 lit/m^3

Cement content = 186/0.43 = 432 kg/m^3

(d) Calculation of aggregate content:-

Volume of cement = 432/ (2.84×1000) = 0.1521 m^3

Volume of water = 186/100 = 0.186 m^3

Volume of all in aggregate = 1- 0.1521- 0.186

= 0.6619 m^3

Coarse aggregate content = 2.85× 0.63 × 0.6619 × 1000 =1188.44 kg/m^3

Fine aggregate content = 2.71 × 0.37 × 0.6619 × 1000 = 663.68 kg/m^3

Table 4.8: Mix Design Proportion of Standard (M 20) Grade Concrete

Mix designation	Water	Cement	Fine aggregate	Coarse aggregate
MX0	186 lt/m^3	432 kg/m^3	663.68 kg/m^3	1188.44 kg/m^3
	.430	1	1.53	2.75

Table 4.9 Marble Dust Based Concrete Mix

Figure 4.7 Mix proportion

Mix designation	Percentage of WMP	Water (kg)	Cement(kg)	Coarse Aggregates(kg)	Fine aggregate(kg)	Marble Powder(kg)
MX0	0	15	34.89	95.94	53.37	0
MX1	5	15	33.146	95.94	53.37	1.744
MX2	7.5	15	32.274	95.94	53.37	2.616
MX3	12.5	15	30.529	95.94	53.37	4.361
MX4	17.5	15	28.785	95.94	53.37	6.105
MX5	22.5	15	27.04	95.94	53.37	7.850

Compressive strength test

Compressive strength of concrete is tested on cube at different percentage of marble powder content in concrete. The strength of concrete has been tested on cube at 7 days curing and 28 days. 7 days test has been conducted to check the gain in initial strength concrete. 28 days test gives the data of final strength of concrete at 28 days curing. Compression testing machine is used for testing the compressive strength test on concrete. At the time of testing the cube is taken out of water and dried and then tested keeping the smooth faces in upper and lower part [20]. The load was applied gradually without any shock and increased at constant rate of 14 N/mm²/minute until failure of specimen takes place, thus the compressive strength of specimen was found out.

Figure 4.11 Testing of Cube Specimen

Tensile Strength test

Tensile strength of concrete is tested on cylinders at different percentage of marble powder content in concrete. The strength of concrete has been tested on cylinder at 7 days curing and 28 days. 7 days 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. Compression testing machine is used for testing the Tensile strength test on concrete along with two wooden boards [9]. At the time of testing the cylinder taken out of water and dried and then tested.

Figure 4.13 Testing of Cylinder Specimen

Flexural Strength test

Flexural strength of concrete is tested on beams at different percentage of marble powder content in concrete. The strength of concrete has been tested on beam at 7 days curing and 28 days. 7 days 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 [10]. Flexural testing machine is used for testing the flexural strength test on concrete.

Compressive Strength

The compressive strength was conducted on various specimens as per the guidelines given in IS 516-1959. The specimens were surface dried before testing the same on Universal Testing Machine of 200 tonnes capacity. The result of compression test using waste marble powder (WMP) in varying percentages i.e. (0%, 5%, 7.5%, 12.5%,17.5% and 22.5%) as partial replacement of sand at the moist curing age of 7days and 28 days are presented in table 5.1 and 5.2. The comparison of various mixes containing WMP in different percentages

Table 5.1 Compressive Strength after 7 Days

Mix Designation	Percentage of marble	Load (kN)	Compressive Strength (N/mm^2)	Average Compressive strength (N/mm^2)
MX0	0	580 620 610	25.77 27.55 27.11	26.81

MX1	5	650 590 665	28.88 26.22 29.55	28.21
MX2	7.5	670 655 690	29.77 29.11 30.66	29.84
MX3	12.5	680 700 660	30.22 31.11 29.33	30.22
MX4	17.5	580 600 550	25.77 26.66 24.44	25.62
MX5	22.5	570 545 530	25.33 24.22 23.55	24.36

Table 5.2 Compressive Strength after 28 Days

Mix Designation	Percentage of Marble	Load (kN)	Compressive Strength (N/mm^2)	Average Compressive strength (N/mm^2)
MX0	0	820 850 810	36.44 37.77 36.00	36.73
MX1	5	880 900 860	39.11 40.00 38.22	39.11
MX2	7.5	950 890 920	42.22 39.55 40.88	40.88
MX3	12.5	900 930 950	40.00 41.33 42.22	41.18
MX4	17.5	820 760 800	36.44 33.77 35.55	35.25
MX5	22.5	730 790 755	32.44 35.11 33.55	33.70

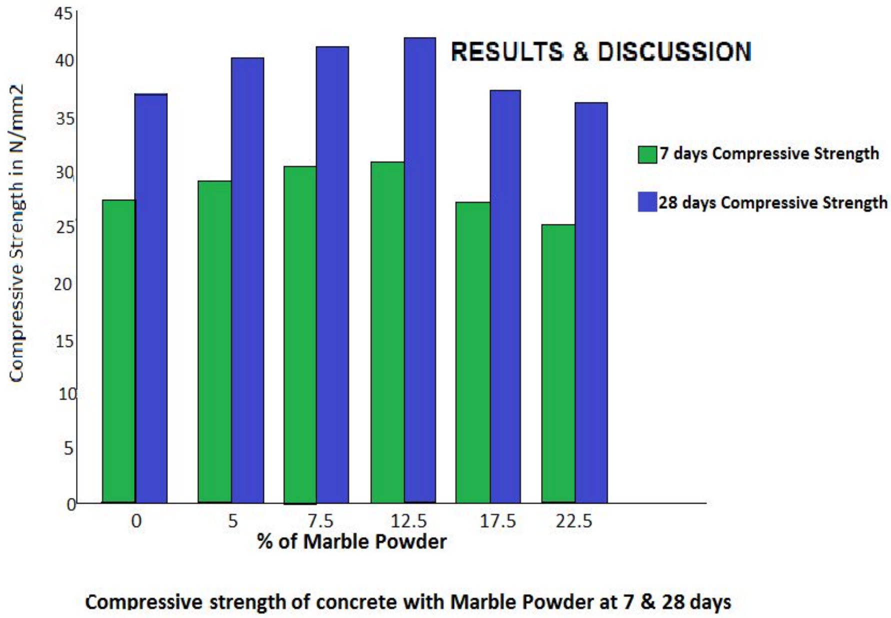

Figure 5.1 Compressive Strength Graph

It can be seen from the above tables and figures that the flexural strength of concrete mixes containing 7.5% and 12.5% WMP are about 3% to 5% higher than the flexural strength of the control mix, however the flexural strength of the mix containing 17.5% and 22.5% WMP are comparable to the compressive strength obtained for the control mix.

Flexure Strength Test

Although the concrete is not designed to resist tension, the knowledge of tensile strength of concrete is of value in assessing the load at which crack will start appearing in concrete. The absence of cracking is of considerable importance in insuring the better durability of concrete structure and in many cases the prevention of the corrosion of the reinforcement because of the partial difficulties faced in conducting a pure strength, it is preferable to measure the tensile strength of the concrete by subjecting a plain concrete beam to flexure. The flexure test was conducted on various mixes. The result obtained for various mixes at the age of 7 days and 28 days.

Table 5.5 Flexure Strength after 7 Days

Mix Designation	Percentage of marble	Flexural Strength (Tonnes)	Flexural Strength (N/mm^2)	Average strength (N/mm^2)
MX0	0	2.08 2.12 2.15	3.69 3.76 3.82	3.75
MX1	5	2.10 2.17	3.73 3.85	3.79
MX2	7.5	2.16 2.22	3.84 3.94	3.89
MX3	12.5	2.20 2.26	3.19 4.01	3.96
MX4	17.5	1.95 1.87 2.00	3.46 3.32 3.55	3.44
MX5	22.5	1.88 1.75 1.80	3.34 3.11 3.20	3.21

Table 5.6Flexure Strength after 28 Days

Mix Designation	Percentage of marble	Flexural Strength (Tonnes)	Flexural Strength (N/mm^2)	Average strength (N/mm^2)

MX0	0	3.10 3.00 3.12	5.51 5.33 5.54	5.46
MX1	5	3.15 3.28 3.19	5.60 5.83 5.67	5.70
MX2	7.5	3.22 3.18 3.28	5.72 5.65 5.83	5.73
MX3	12.5	3.20 3.29 3.26	5.68 5.84 5.79	5.77
MX4	17.5	3.00 2.89 2.74	5.33 5.13 4.87	5.11
MX5	22.5	2.80 2.72 2.68	4.97 4.83 4.76	4.85

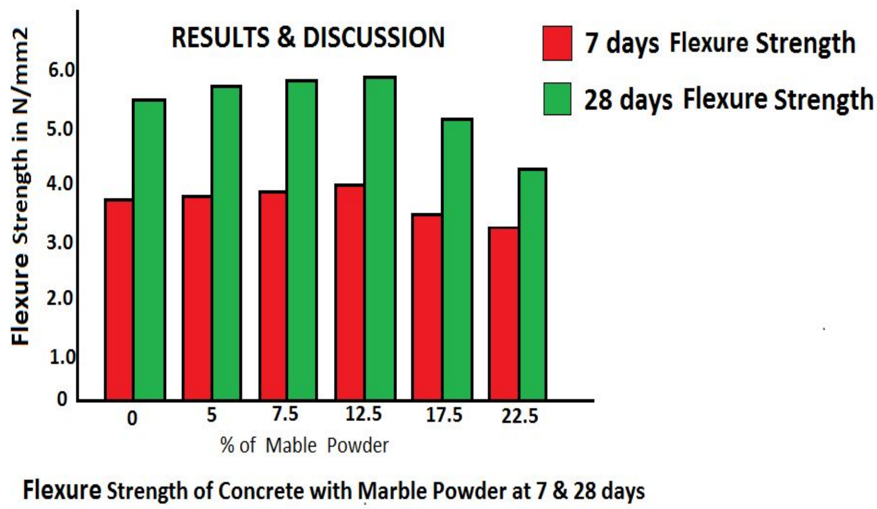

Figure 5.3 Flexure Strength Graph

It can be seen from the above tables and figures that the flexural strength of concrete mixes containing 7.5% and 12.5% WMP are about 3% to 5% higher than the flexural strength of the control mix; however the flexural strength of the mix containing 17.5% and 22.5% WMP are comparable to the flexural strength obtained for the control mix. This trend is similar to the trends obtained for compressive strength and tensile strength and the reason for the same is as already explained.

CONCLUSIONS

Based on the experimental results obtained from this study, the following conclusions can be drawn:

- A 10% WMD can be used as an additive material in production of cement.
- Use of WMD in production of WMDCs does not affect the setting time.
- The ratio of WMD in the cements increases the values of specific gravity and specific surface decrease.
- There is a linear relationship between WMD and quantities of cement retained on sieve.
- it proved to be very effective in assuring very good cohesiveness of mortar and
- Concrete.
- The compressive strength of WMD MX4 is higher than those of OPC.
- The study indicates that the marble waste can be incorporated in Portland limestone production.
- Cost of cement production can be decreased by use of 10% WMD.
- The Compressive strength of Cubes are increased with addition of waste marble
- Powder up to 12.5 % replace by weight of cement and further any addition of waste
- Marble powder the compressive strength decreases.

Thus we found out the optimum percentage for replacement of marble powder withcement and it is almost 12.5 % cement for both cubes and cylinders.

We have put a simple step to minimize the costs for construction with usage of
Marble powder which is freely or cheaply available more importantly.

REFERENCES

1. Prof. P.A. Shirule , Ataur Rahman , Rakesh D. Gupta PARTIAL REPLACEMENT OF CEMENT WITH MARBLE DUST POWDER International Journal of Advanced Engineering Research and Studies VOL.1 June 2012 E-ISSN2249–8974
2. Ali Ergun (2011), "Effects of the usage of diatomite and waste marble powder as partial replacement of cement on the mechanical properties of concrete", Construction and Building Materials, 25(2), pp 806812.
3. [http://www.engineeringcivil.com/project-on-partialreplacement-Of-cement-with- marble-powder
4. Huseyin Yılmaz Aruntas , Metin Guru, Mustafa Dayı , Ilker Tekin ," Utilization of waste marble dust as an additive in cement production" Materials and Design 31 (2010) 4039–4042
5. Valeria Corinaldesi, Giacomo Moriconi, Tarun R. Naik,"Characterization of marble powder for its use in mortar and concrete" Construction and Building Materials 24 (2010) 113–117
6. Ali A. Aliabdo, Abd Elmoaty M. Abd Elmoaty, Esraa M. Auda," Re-use of waste marble dust in the production of cement and concrete" Construction and Building Materials 50 (2014) 28–41
7. Prof. Veena G. Pathan, Prof. Md. Gulfam Pathan," Feasibility and Need of use of Waste Marble Powder in Concrete Production" *e-ISSN: 2278-1684, p-ISSN: 2320-334X*
8. Deborah .O.Olanrewaju," EXPERIMENTAL STUDY ON THE PARTIAL REPLACEMENT OF CEMENT BY MARBLE DUST ON CONCRETE"
9. Indian Journal of Engineering," Study on marble dust as partial replacement of cement in concrete" VOL.4, NUMBER 9, JULY 2013
10. Baboo Rai, Khan Naushad H , Abhishek Kr, Tabin Rushad S, Duggal S.K ," Influence of Marble powder/granules in Concrete mix " International Journal of Civil and Structural Engineering Volume 1, No 4, 2011.
11. M. S. Shetty "CONTRETE TECHNOLOGY", 3rd Edition, S. Chand & Company Limited, Delhi, 1992.
12. "ENGINEERING MATERIALS "by RANGWALA.
13. "Investigations on partial replacement of cement with marble powder" by Rahul, Jagadeesh in INTERNATIONAL JOURNAL OF CIVIL AND STRUCTURAL ENGINEERING, Volume 1, No 3, 2010.
14. DESIGN MIX BY KRISHSNA RAJU
15. *Bahar* Demirel," The effect of the using waste marble dust as fine sandon the mechanical properties of the concrete" International Journal of the Physical Sciences Vol. 5(9), pp. 1372-1380, 18 August, 2010
16. B.V.Bahoria, Dr.D.K.Parbat , Dr.P.B.Naganaik , Dr.U.P.Waghe ," Comprehensive literature review on use of waste product in concrete" International Journal of Innovation in Engineering & Management VOL.2 April 2013
17. G. Marras, N. Careddu, C. Internicola, G. Siotto," RECOVERY AND REUSE OF MARBLE POWDER BY-PRODUCT" *Global Stone Congress 2010*
18. TASNIA HOQUE, MUHAMMAD HARUNUR RASHID, MD. ROKON HASAN, EBNA FORHAD MONDOL," Influence of Stone Dust as Partially Replacing Material of Cement and Sand on some Mechanical Properties of Mortar" *International Journal of Advanced Structures and Geotechnical Engineering ISSN 2319-5347, Vol. 02, No. 02, April 2013*
19. Hassan A. Mohamadien," The Effect of marble powder and silica fume as partial replacement for cement on mortar" INTERNATIONAL JOURNAL OF CIVIL AND STRUCTURAL ENGINEERING Volume 3, No 2, 2012
20. Ankit Nileshchandra Patel," Stone Waste in India for Concrete with ValueCreation Opportunities" International Journal of Latest Trends in Engineering and Technology (IJLTET) Vol. 2 Issue 2 March 2013
21. Ram Joshi," Effect of using selected industrial waste on compressive and flexural strength of concrete" INTERNATIONAL JOURNAL OF CIVIL AND STRUCTURAL ENGINEERING Volume 4, No 2, 2013
22. Indian standard code IS 456-200 ,10262-1982 , IS:383-1970.
23. Ankit Nileshchandra Patel, Jayeshkumar Pitroda," Stone Waste: Effective Replacement Of Cement For Establishing Green Concrete" ISSN: 2278-3075, Volume-2, Issue-5, April 2013
24. P. McEleney, G.M.Walker, I.A. Larmour, S.E.J. Bell," Liquid marble formation using hydrophobic powders" Chemical Engineering Journal 147 (2009) 373–382
25. Gavin M. Walker, P. McEleney , Ala'a H. Al-Muhtaseb , S.E.J. Bell ," Liquid marble granulation using super-hydrophobic powders" Chemical Engineering Journal 228 (2013) 984–992
26. *Hanifi Binici , Tahir Shah, Orhan Aksogan, Hasan Kaplan,"* Durability of concrete made with granite and marble as recycle aggregates" journal of materials processing technology 2 0 8 (2 0 0 8) 299–308
27. F. Saboya Jr., G.C. Xavier, J. Alexandre," The use of the powder marble by-product to enhance the properties of brick ceramic" Construction and Building Materials 21 (2007) 1950–1960
28. Neeraj Jain, Mridul Garg," Effect of Cr(VI) on the hydration behavior of marble dust blended cement: Solidification, leachability and XRD analyses" Construction and Building Materials 22 (2008) 1851–1856
29. Kursat Esat Alyamac, Ragip Ince ," A preliminary concrete mix design for SCC with marble powders" Construction and Building Materials 23 (2009) 1201–1210
30. C. Borsellino , L. Calabrese , G. Di Bella ,* Effects of powder concentration and type of resin on the performance of marble composite structures" Construction and Building Materials 23 (2009) 1915–1921
31. H. Hebhoub , H. Aoun ,, M. Belachia , H. Houari , E. Ghorbel ," Use of waste marble aggregates in concrete" Construction and Building Materials 25 (2011) 1167–1171
32. N. Bilgin , H.A. Yeprem , S. Arslan , A. Bilgin , E. Gunay , M. Mars_oglu," Use of waste marble powder in brick industry" Construction and Building Materials 29 (2012) 449–457
33. A.S.E. Belaidi , L. Azzouz , E. Kadri , S. Kenai," Effect of natural pozzolana and marble powder on the properties of self-compacting concrete" Construction and Building Materials 31 (2012) 251–257
34. Mehmet Gesoglu , Erhan Guneyisi , Mustafa E. Kocabag , Veysel Bayram , Kasım Mermerdas ," Fresh and hardened characteristics of self compacting concretes made with combined use of marble powder, limestone filler, and fly ash" Construction and Building Materials 37 (2012) 160–170
35. Oguzhan Keles_temur, Erdinc Arıcı , Servet Yıldız, Bihter Gokcer ," Performance evaluation of cement mortars containing marble dust and glass fiber exposed to high

temperature by using Taguchi method" Construction and Building Materials 60 (2014) 17–24

36. H.A.F. Dehwah ," Corrosion resistance of self-compacting concrete incorporating quarry dust powder, silica fume and fly ash" Construction and Building Materials 37 (2012) 277–282
37. M.K. Rahman, M.H. Baluch, M.A. Malik ," Thixotropic behavior of self compacting concrete with different mineral Admixtures" Construction and Building Materials 50 (2014) 710–717
38. Mucteba Uysal , Kemalettin Yilmaz," Effect of mineral admixtures on properties of self-compacting concrete" Cement & Concrete Composites 33 (2011) 771–776
39. Rania A. Hamza, Salah El-Haggar, and Safwan Khedr ," Marble and Granite Waste: Characterization and Utilization in Concrete Bricks" *International Journal of Bioscience, Biochemistry and Bioinformatics, Vol. 1, No. 4, November 2011*
40. Portland Cement,en.wikipedia.org/wiki/Portland-cement
41. Osman Gencel, Cengiz Ozel, Fuat Koksal, Ertugrul Erdogmus,Go nzalo Martínez-Barrera, Witold Brostow,," Properties of concrete paving blocks made with waste marble" Journal of Cleaner Production 21 (2012) 62-70
42. M. Shahul Hameed and A. S. S. Sekar ," PROPERTIES OF GREEN CONCRETE CONTAINING QUARRY ROCK DUST AND MARBLE SLUDGE POWDER AS FINE AGGREGATE" ARPN Journal of Engineering and Applied Sciences VOL. 4, NO. 4, JUNE 2009
43. IS Code 10262-1982
44. Veerle Bams , Stijn Dewaele ," Staining of white marble" Materials Characterization 58 (2007) 1052–1062