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Effect of Variable Density Plastic Granules and Marble Powder on the Performance of Blended Concrete

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Abstract: The reuse of plastic is crucial in addressing environmental concerns. Incorporating waste plastics into concrete by converting them into aggregates presents a viable solution for their disposal. This study examines the mechanical behavior of concrete incorporating waste Low-Density Polyethylene (LDPE) granules as a partial replacement for coarse aggregates. It also explores the combined utilization of recycled plastic and marble powder as partial substitutes for coarse aggregates and cement, respectively. LDPE waste was collected and blended with Ordinary Portland Cement (OPC) at varying proportions (0%, 20%, 30%, and 40%) to replace coarse aggregates. Additionally, marble powder was used to replace cement in proportions of 5%, 10%, and 15% for each variation of plastic granules. The workability, compressive strength, and split tensile strength of the prepared concrete mixes were evaluated.

Keywords: concrete; aggregates; plastic; characteristics; strength

Introduction

A wide range of waste materials, such as fly ash, silica fume, marble waste, industrial byproducts, and agricultural residues, are increasingly used in construction products like fly ash concrete and jute fiber composites. Among these, plastic waste, generated in massive quantities worldwide in the form of carry bags, polyethylene bags, bottles, and scrap, poses significant environmental challenges due to its low biodegradability. Addressing this issue, this study investigates the potential of replacing coarse aggregates in concrete with plastic granules.

The research aims to evaluate the performance of concrete when normal aggregates are replaced with plastic granules, focusing on its workability, strength, and load-bearing capacity. Aggregates significantly impact the fundamental properties of concrete (Muhit et al., 2013). Additionally, marble powder was examined as a partial cement replacement, though its use has been found to reduce compressive strength in some cases (Bajad et al., 2012). This study highlights the viability of using waste plastic and marble powder as sustainable construction materials to enhance environmental management and resource utilization.

Literature Review

Coarse aggregate is a critical component of concrete, significantly influencing its mechanical properties and functionality. Numerous studies have explored the impact of aggregate shape, size, and characteristics on concrete performance.

Ponnada (2014) investigated the combined effects of flaky and elongated aggregates on the strength and workability of M25 grade concrete. The study tested various ratios of elongated-to-flaky aggregates and angular-to-total aggregates to evaluate the mechanical properties of the prepared concrete. Similarly, Muhit et al. (2013) examined the influence of different aggregate types on concrete properties while maintaining a constant water-to-cement (w/c) ratio. The study highlighted the role of aggregate shape and grading in influencing concrete behavior.

Jakarsi (2013) assessed the effects of flaky aggregates on concrete properties, demonstrating that their presence impacts strength. The research included mixes with varying proportions of flaky aggregates. Singh and Biswas (2013) noted that flaky aggregates possess a higher relative surface area, increasing bitumen requirements in asphalt mixtures and reducing the strength of pavement layers due to breakage during rolling. They emphasized the importance of maintaining aggregate grading and size consistency during practical applications.

Naidu and Adiseshu (2013) explored the strength and workability of hot mix asphalt, showing that the physical properties and shapes of aggregates significantly influence dense bituminous macadam mixtures. Ryza et al. (2013) demonstrated the connection between aggregate particle shape and several concrete properties, including stability, rut resistance, shear resistance, and tensile strength. Advanced imaging techniques have been employed to analyze aggregate shape characteristics.

Patil and Sangle (2013) studied the substitution of cement with marble powder, observing the effects on concrete strength. They categorized marble powder into two particle size ranges to evaluate its influence. Khatib et al. (2012) examined the use of marble powder as a partial cement replacement and reported the results of ultrasonic pulse velocity, compressive strength, and absorption tests.

Jain and Chouhan (2011) highlighted the significant impact of aggregate shape on the compressive strength and permeability of pervious concrete. Their laboratory investigations used aggregates of varying shapes and water-to-cement ratios. Adom-Asamoah and Afrifa (2011) tested reinforced concrete beams made with coarse aggregates, finding that premature shear failures occurred more frequently than expected. Displacement flexibility was noted to be low despite adherence to design codes.

Othman et al. (2010) analyzed Marshall test results to understand the effects of cubical aggregates on mix properties. Similarly, Hamzah et al. (2010) investigated the mechanical properties of mixtures incorporating cubical aggregates with varying sharpness degrees, revealing significant impacts on stability and flow characteristics.

Vyawahare and Modani (2009) focused on improving concrete workability and strength by incorporating flaky and elongated aggregates with superplasticizers and admixtures. The researchers also examined marble powder's suitability as a sand replacement, as reported by Taha and Nounu (2009). They found no significant differences in compressive strength but observed improved durability.

Agarwal et al. (2007) explored the grading properties of fine aggregates like sand, categorized as fine, medium, and coarse, to optimize concrete mixes. Chen et al. (2005) evaluated aggregate characteristics, including shape, and their influence on concrete properties. The study correlated the angularity and shape factors of aggregates with their mechanical interlocking capabilities.

Siswosoebrotho et al. (2005) investigated the effects of varying flaky aggregate content on asphalt mixtures, highlighting changes in optimal asphalt content with increasing flaky aggregate proportions. Kaplan (1958) examined various aggregate types to determine the influence of shape, texture, permeability, and porosity on workability, concluding that increased angularity enhances concrete functionality.

These studies collectively emphasize the critical role of aggregate characteristics in determining the performance, durability, and workability of concrete and other construction materials

Experimental Examinations

A series of laboratory tests were conducted to evaluate the properties of various concrete mixes. Concrete with a target strength of 20 MPa was prepared using 53-grade Ordinary Portland Cement as the binder. River sand with a fineness modulus of 2.27 was used as the fine aggregate, and the water-to-cement (w/c) ratio for each mix ranged between 0.45 and 0.55.

In the prepared samples, cement was partially replaced with marble powder, and coarse aggregate was partially replaced with plastic granules. The details of the prepared concrete mixes are presented in Table 1.

Table 1: Composition of Prepared Concrete Mixes

Mix no.	Mixes with Marble powder	Cement	Marble Powder	Aggregates			% Plastic Granules
				Plastic Granules	Normal	Fine	
M1	M11	0.95	0.05	0	3.4	1.62	0
	M12	0.9	0.1				
	M13	0.85	0.15				
M2	M21	0.95	0.05	0.4	3.0	1.62	12
	M22	0.9	0.1				
	M23	0.85	0.15				
M3	M31	0.95	0.5	0.6	2.8	1.62	18
	M32	0.9	0.1				

	M33	0.85	0.15				
M4	M41	0.95	0.5	0.8	2.6	1.62	24
	M42	0.9	0.1				
	M43	0.85	0.15				
M5	M51	0.95	0.5	1	2.4	1.62	30
	M52	0.9	0.1				
	M53	0.85	0.15				
M6	M61	0.95	0.5	1.2	2.2	1.62	36
	M62	0.9	0.1				
	M63	0.85	0.15				
M7	M71	0.95	0.5	1.4	2.0	1.62	42
	M72	0.9	0.1				
	M73	0.85	0.15				
M8	M81	0.95	0.5	1.6	1.8	1.62	48
	M82	0.9	0.1				
	M83	0.85	0.15				
M9	M91	0.95	0.5	1.8	1.6	1.62	54
	M92	0.9	0.1				
	M93	0.85	0.15				
M10	M101	0.95	0.5	2.0	1.4	1.62	60
	M102	0.9	0.1				
	M103	0.85	0.15				

Table 2 summarizes the experimental results for compressive strength, workability, and split tensile strength of the produced concrete. The following observations were made:

1. An increase in the proportion of plastic granules leads to a reduction in both compressive strength and slump value of the concrete.
2. For a fixed proportion of plastic granules, a higher percentage of marble powder enhances the compressive strength of the concrete.
3. Increasing the percentage of marble powder decreases the slump value for a given proportion of plastic granules.

Table 2- Experimental results

S. No.	Mixes with variation in Marble powder	% of Marble powder in Cement	Plastic Granules / Normal Aggregate	Compressive strength in MPa	Slump in mm	Split Tensile strength in MPa
1	M11	5	0	19.1	97	5.1
2	M12	10		19. 3	95	4.6
3	M13	15		19.8	94	4.3
4	M21	5	12	18.6	93	4.59
5	M22	10		18.9	91	4.14
6	M23	15		19.4	88	3.87
7	M31	5	18	18.4	89	4.13
8	M32	10		18.7	87	3.73
9	M33	15		19.3	84	3.48
10	M41	5	24	18.1	86	3.72
11	M42	10		18.7	83	3.35
12	M43	15		19.1	82	3.13
13	M51	5	30	17.9	82	3.35
14	M52	10		18.3	80	3.02
15	M53	15		18.6	77	2.82
16	M61	5	36	17.6	79	3.01

17	M62	10		18.2	77	2.72
18	M63	15		18.5	74	2.54
19	M71	5	42	17.1	76	2.71
20	M72	10		17.8	73	2.44
21	M73	15		18	72	2.29
22	M81	5	48	17	73	2.44
23	M82	10		17.4	70	2.2
24	M83	15		17.9	67	2.06
25	M91	5	54	16.8	68	2.2
26	M92	10		17.4	65	1.98
27	M93	15		17.7	63	1.85
28	M101	5	60	16.2	64	1.98
29	M102	10		16.9	62	1.78
30	M103	15		17.3	60	1.67

To obtain the combined effect of proportions of Plastic Granules and Marble powder following figures 1 to 10 were drawn. All these figures present the variation of compressive strength and slump height with the change in proportion of Marble in cement, at a constant percentage of Plastic Granules.

From all the figures it has been observed that with the increase in Marble powder percentage compressive strength increases when compared to concrete prepared by using ordinary 53 grade of cement and natural aggregates. Slump height or workability has been decreases by increasing the percentage of Marble powder.

When no Plastic Granules has been added or used to replace normal aggregates, the compressive strength increases with the increase in percentage of Marble powder and almost equal to the strength obtained by using 100% cement. However, workability in terms of slump height reduces when proportion of Marble powder increases. Same trend of variation has been observed in concrete with 12% replacement of normal aggregate with Plastic Granules however, initial strength obtained is lower than above case. Hence, it may be said that with the increase in Plastic Granules compressive strength decreases.

(i) Plastic Granules 0%

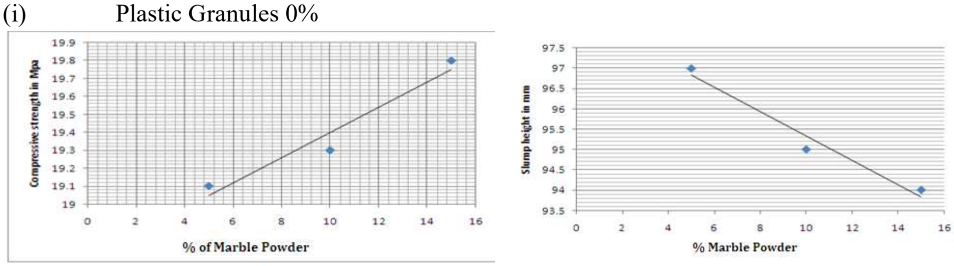

Fig 1 – 0% Plastic Granules

(ii) Plastic Granules 12%

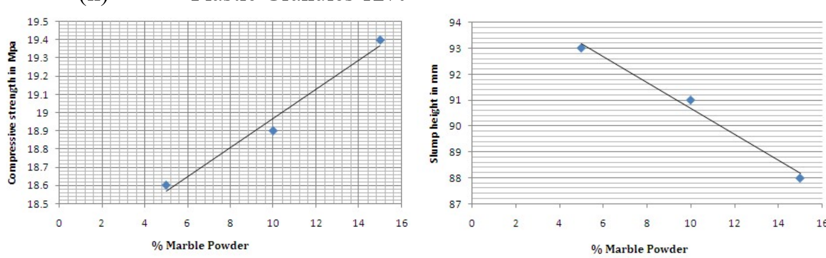

Fig 2 – 12% Plastic Granules

(iii) Plastic Granules 18%

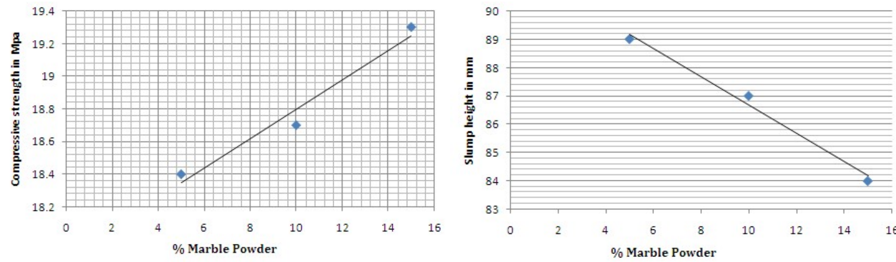

Fig 3 – 18% Plastic Granules

(iv) Plastic Granules 24%

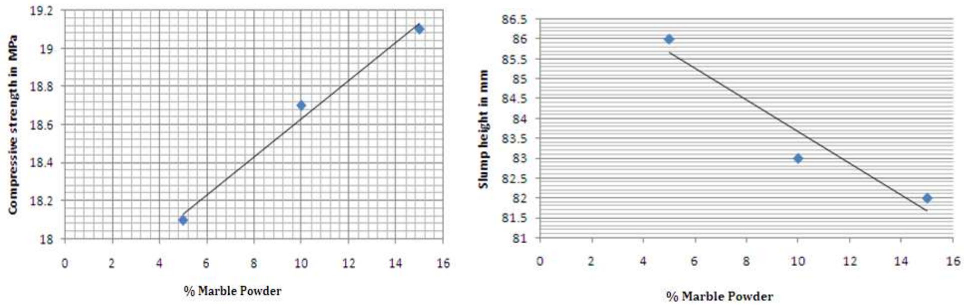

Fig 4 – 24% Plastic Granules

(v) Plastic Granules 30%

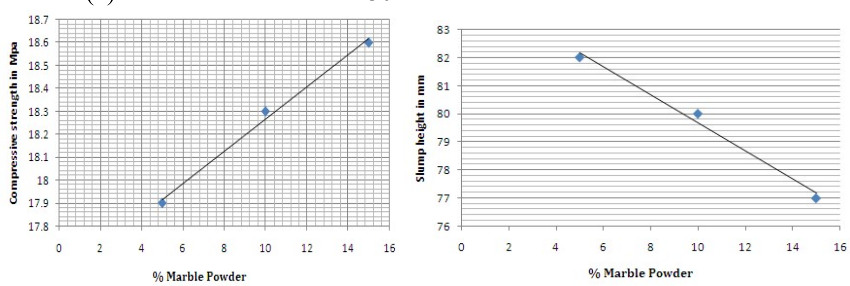

Fig 5 – 30 % Plastic Granules

(vi) Plastic Granules 36%

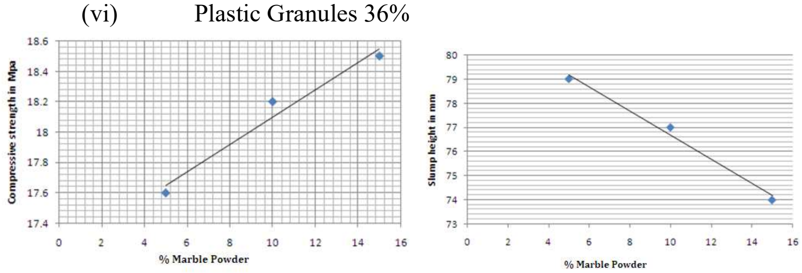

Fig 6 – 36% Plastic Granules

(vii) Plastic Granules 42%

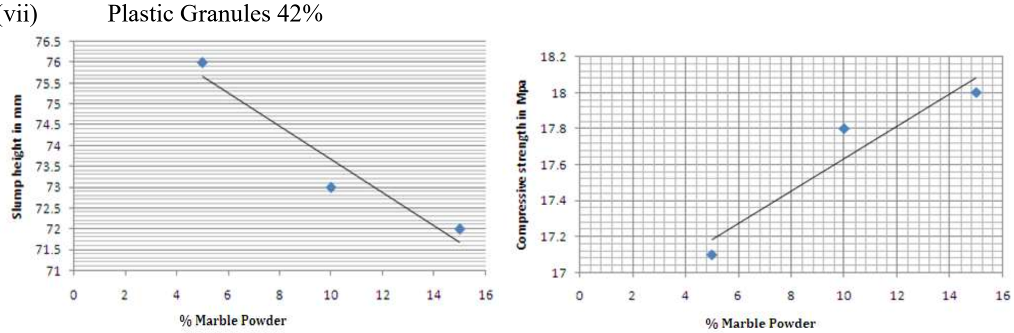

Fig 7– 42% Plastic Granules

(viii) Plastic Granules 48%

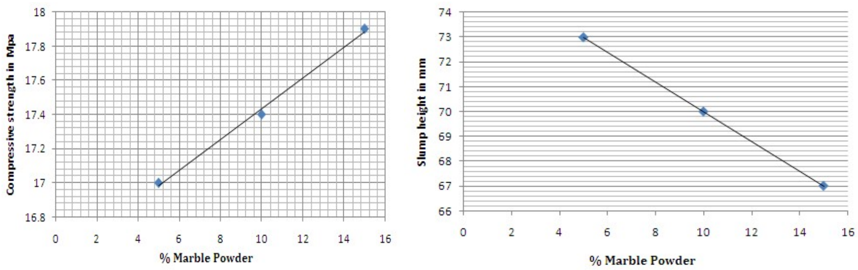

Fig 8 – 48% Plastic Granules

(ix) Plastic Granules 54%

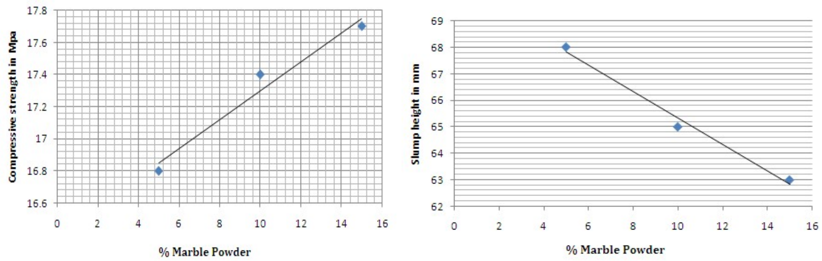

Fig 9 – 54% Plastic Granules

(x) Plastic Granules 60%

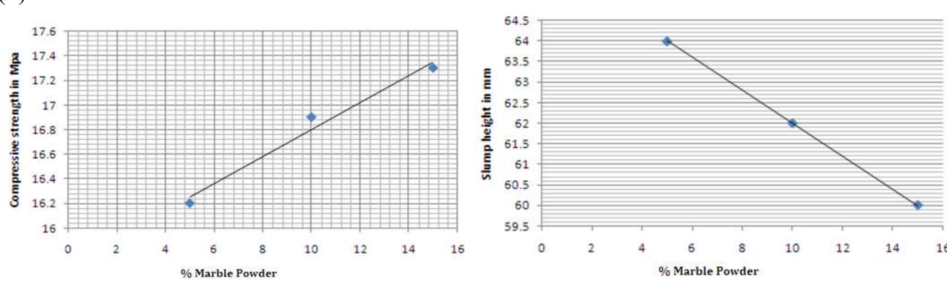

Fig 10 –60% Plastic Granules

4. Conclusions and Discussion

An experimental study has been performed to evaluate the combined effect of using partially Plastic Granules and Marble powder over the compressive strength, Split Tensile strength and workability of concrete. Following are the observations–

1. It has been observed from that concrete mixtures formed with 0 and 12% replacement of normal aggregate with Plastic Granules is almost equivalent with the values of 100% normal aggregate.
2. With the increase in percentage of Plastic Granules values of compressive strength, Split Tensile strength and slump cone reduces.
3. Additional effect of Marble powder variation over the effect of Plastic Granules has been determined by replacing cement by Marble powder in different proportions such as 5%, 10% and 15% for each variation of Plastic Granules.
4. Increase in percentage of Marble powder increases the compressive strength and tensile strength for a Plastic Granules proportion.
5. Increase in percentage of Marble powder reduces the slump value for a Plastic Granules proportion.
6. Hence, it has been observed that replacing normal aggregate with Plastic Granules reduces the workability of concrete, and after 40% replacement concrete becomes very poor in terms of workability and strength.

References-

1. Adom-Asamoah M, Afrifa R O "Investigation On The Flexural Behaviour Of Reinforced Concrete Beams Using Phyllite Aggregates From Mining Waste" Materials & Design, 32(10), 5132-5140, 2011

2. Agrawal P., GuptaY.P., Bal S. "Effect Of Fineness Of Sand On The Cost And Properties Of Concrete" Nbmcw October 2007

3. Altaf et al. (2013) "Suitability Of Waste Marble Powder As A Partial Replacement Of Cement In Fibre Reinforced Concrete" Project Report, A.I.A.R. KALSEKAR POLYTECHNIC New Panvel 410 206, Navi Mumbai.
4. Animesh Mishra, Abhishek Pandey, Prateek Maheshwari, Abhishek Chouhan, S. Suresh, Shaktinath Das "Green Cement For Sustainable Concrete Using Quarry dust Dust"
5. Baboo Rai, Khan Naushad H , Abhishek Kr, Tabin Rushad S, Duggal S.K "Influence of Quarry dust powder/granules in Concrete mix"
6. Baboo Rai, Sanjay Kumar, and Kumar Satish "Effect of Fly Ash on Mortar Mixes with Quarry Dust as Fine Aggregate"
7. Bahar Demirel "The effect of the using waste quarry dust dust as fine sand on the mechanical properties of the concrete"
8. Bant Singh, Dr, and Srijit Biswas. "Upgrading Properties of Aggregates in Flexible Pavements with e-Control."International Journal of Scientific & Engineering Research, Volume 4, Issue 9, September-2013 2543 ISSN 2229-5518
9. Chandana Sukesh, Katakam Bala Krishna, P.Sri Lakshmi Sai Teja, S.Kanakambara Rao "Partial Replacement of Sand with Quarry Dust in Concrete"
10. Chen J., LinK.Y., ChangM.K. "Influence Of Coarse Aggregate Shape On The Strength Of Asphalt Concrete Mixtures" Journal Of The Eastern Asia Society For Transportation Studies, Vol. 6, Pp. 1062 - 1075, 2005
11. Corinaldesi V, Moriconi G, Naik TR. "Characterization of Quarry dust Dust for its use in Mortar and Concrete", CANMET / ACI Three day International symposium on Sustainable development of Cement and Concrete, October 5 – 7, 2005, Toronoto, Canada
12. Hamzah M O, Puzi M A A, Azizli K A M "Properties Of Geometrically Cubical Aggregates And Its Mixture Design" Ijrras 3 (3) ● June 2010
13. Hassan A. Mohamadien" The Effect of quarry dust powder and silica fume as partial replacement for cement on mortar"Proceedings of the International Congress IMTCR, Lecce, Italy, 2004
14. Jain A K, Chouhan J S (2011) "Effect of Shape of Aggregate on compressive strength And Permeability Properties of Pervious Concrete" International Journal of Advanced Engineering Research and Studies E-ISSN2249 – 8974
15. Jarkasi, Mohd. Daud (2013) *Influence Of Aggregate Flakiness On Marshall Properties For Asphaltic Concrete (Ac14) Mixture.* M. Tech. thesis, Universiti Teknologi Malaysia, Faculty Of Civil Engineering.
16. K. Subramanian, A. Kannan " An Experimental Study On Usage Of Quarry Dust As Partial Replacement For Sand In Concrete And Mortar"
17. Kandekar S B, Mehetre A J, Auti V A "Strength Of Concrete Containing Different Types Of Fine Aggregate" International Journal Of Scientific & Engineering Research Volume 3, Issue 9, September-2012
18. Kaplan M F "The Effects Of The Properties Of Coarse Aggregates On The Workability Of Concrete" **Magazine Of Concrete Research**,**Volume 10, Issue 29**, 01 August 1958 , Pages 63 –74
19. Khatib J.M., Negim E.M., Sohl H.S., ChilesheN. "Marble Powder Utilisation in Concrete Production" European Journal of Applied Sciences 4 (4): 173-176, 2012.
20. M. N. Bajad, C. D. Modhera, A. K. Desai "Resistance of Concrete Containing Waste Marble Powder against M_gSO_4 Attack" NMBCW MAY 2012
21. M.S. Hameed, A.S.S. Sekar, "Properties of green concrete containing quarry rock dust and quarry dust sludge powder as fine aggregate". India, ARPN Journal of Engineering and Applied Sciences 4 (4) (2009) 83–89.
22. Meena Ankur and Singh Randheer (2012) "Comparative Study of Waste Marble Powder as Pozzolanic Material in Concrete" B. Tech thesis, NIT Rourkela.
23. Muhit, I. B., S. Haque, And Md. Rabiul Alam. "Influence Of Crushed Coarse Aggregates On Properties Of Concrete."American Journal Of Civil Engineering And Architecture 1, No. 5 (2013): 103-106.
24. Nutan Patel, Amit Raval, Jayeshkumar Pitroda "Quarry dust Waste: Opportunities For Development of Low Cost Concrete"
25. Patil D.M., Sangle KK. "Experimental Investigation of Waste Marble Powder as Partial Replacement of Cement in Concrete" International Journal of Advanced Technology in Civil Engineering, ISSN: 2231 –5721, Volume-2, Issue-1, 2013.
26. Polat, Rýza, et al. "The correlation between aggregate shape and compressive strength of concrete: digital image processing approach."*International Journal of Structural and Civil Engineering Research* (2013): 1-19.
27. Ponnada M R (2014) "Combined Effect Of Flaky And Elongated Aggregates On Strength And Workability Of Concrete" Int. J. Of Structural Engineering, 2014 Vol.5, No.4, Pp.314 – 325

28. P.A. Shirule, Ataur Rahman , Rakesh D. Gupta “Partial replacement of cement with quarry dust dust powder” March 2011
29. Radhikesh P. Nanda, Amiya K. Das, Moharana.N.C “Stone crusher dust as a fine aggregate in Concrete for paving blocks”
30. Shayan and Xu (2006) “Performance of Marble powder as a pozzolanic material in concrete: A field trial on concrete slabs” Cement and Concrete Research 36 (2006) 457–468.
31. Shetty, M.S. (2003 Edition) Concrete Technology: Theory And Practice, S. Chand & Company Ltd, India.
32. Siswosoebrotho B I, Soedirdjo T L, Ginting K “Workability And Resilient Modulus Of Asphalt Concrete Mixtures Containing Flaky Ggregates Shape” Journal Of The Eastern Asia Society For Transportation Studies, Vol. 6, Pp. 1302 - 1312, 2005
33. Taha B.,Nounu G. “Utilizing waste recycled Marble as sand/cement replacement in concrete” J. Mat. Civil. Engg., 21(12), 709-721.(2009)
34. Tan K.W., Du H. “Use of waste Marble as sand in mortar: part I- fresh, mechanical and durability properties”. Cem. Conc. Comp., 35, 109-117.
35. Vasudevan G., Pillat SGK (2013) “Performance of Using Waste Marble Powder In Concrete As Replacement Of Cement” American Journal of Engineering Research, Volume -02, Issue-12, pp-175-181.
36. Vyawahare M R, Modani P O “Improvement In Workability And Strength Of Concrete With Flaky And Elongated Aggregates” 34thconference On Our World In Concrete & Structures: 16 - 18 August 2009, Singapore