IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 2 Issue 6, June 2015.
www.ijiset.com
ISSN 2348 – 7968

Replacement Of Cement By Marble Dust And Ceramic Waste In Concrete For Sustainable Development

Abdullah Anwar[1], Sabih Ahmad[2], Syed Mohd. Ashraf Husain[3] and Syed Aqeel Ahmad[4]

[1] Civil Engineering Department, Integral University, Lucknow, Uttar Pradesh (226022), India

[2] Civil Engineering Department, Integral University, Lucknow, Uttar Pradesh (226022), India

[3,4] Civil Engineering Department, Integral University, Lucknow, Uttar Pradesh (226022), India

Abstract

Production of residues from industries and construction sectors has increased during last few years. Much of this wasteland has been land filled, without seeing it's possible for reuse or recycling. In the ceramic industry, nearly 15%-30% production goes as waste. The replacement of cement with Ceramic Waste Powder (CWP) or Marble Dust Powder (MDP) produces a substantial modification in compressive strength, making them suitable for the fabrication of concrete. In this research study the (OPC) cement has been replaced by both CWP and MDP accordingly in the reach of 0%, 5%, 10%, 15%, 20%, 25%, 30%, 35%, 40%, 45%, 50% by weight of M-20 grade concrete. Concrete mixtures were tested and compared in terms of compressive strength of the conventional concrete at 28 days. The aim of this research study is to study the behavior of concrete durability in comparison by partial replacement of cement with both CWP and MDP.

K**eywords:** *Ceramic Waste, Compressive Strength, Marble Dust Powder, OPC Cement, Sustainable Development.*

1. Introduction

The overall size of the Indian ceramic industry is about Rs 18,000 crores producing 100 Million tons per year. The production during 2011-12 stood at approx. 600 million square meters. However, the ceramic waste is durable, hard and highly resistant to biological, chemical and physical degradation. Different types of ceramic products are:

- Wall And Floor Tiles
- Bricks And Roof Tiles
- Table-And Ornamental ware (Household Ceramics)
- Refractory Products
- Sanitary ware
- Vitrified Clay Pipes
- Expanded Clay Aggregates

In the ceramic industry, nearly 15%-30% waste material generated from the full production. These wastes are not recycled in any course at present owning a problem in present-day society. Thus, a suitable form of management is required in society to attain sustainable growth. These industries are dumping the waste powder in any nearby pit or vacant spaces, near their unit, although notified areas have been marked for dumping. This contributes to severe environmental and dust pollution and occupation of a immense expanse of solid ground, especially after the powder dries up and then it is necessary to throw out the ceramic waste quickly and employ in the construction industry. As the ceramic waste piles up every day, there is a pressure on ceramic industries to get a resolution for its disposition. Thus, employment of the CWP and MDP in various industrial sectors, especially the building industry would help to protect the surroundings. Thus, resulting in the growth of eco-friendly concrete. Ceramic waste is of generally two types, waste earthenware and also broke up during the fabrication operation. Ceramic waste is seen as non-hazardous solid waste and possesses Pozzolanic properties. Therefore, after recycling can be reused in different building construction application [1,2,3,4,5]. Industrial wastes coarser than cement particles generally uses as fine and coarse aggregate in concrete mix up to 35% tile waste [6, 7]. Utilization of non-hazardous industrial waste is also gaining popularity in India to use in building construction employment for training building material elements. The waste was used in cement concrete up to 20% of conventional coarse aggregate is due to high absorption coefficient (0.5%) and achieved compressive strength approximately 50Mpa with and without super plasticizer additives [8,9,10].

Marble is a metamorphic rock produced from limestone by pressure and heat in the earth's crust due to geological process [11]. Marble Dust Powder is an industrial waste made from cutting of marble rock. In INDIA, the marble processing is one of the most booming industries. Marble

industries in India grow more than 3500 metric tons of marble powder slurry per day. India is among the top

ISSN 2348 – 7968

world exporters of marble rock. The Indian marble industry has been rising steadily at an annual pace of about 10% per year. 20 to 30% of marble blocks are changed into powder. 3,172 M tons of marble dusts were produced in year 2009-10. Recently, marble dust powder has been employed in the construction industry and research has been carried on to examine their fruitful result. Soon, big amount of marble dust is taken forth in natural stone processing plants with an important impact on the environment and humans. Going along the waste materials to the environment right away can cause environmental problems (Siddharth Pareek, 2001; Binici et al. 2007; Stone 2000; 1998; 1992; Kearey, 2001) [12] - [15]. Valeria et al (2005) in their study observed that marble powder had very high Blaine fineness value of approximately 1.5 m^2/g, with 90% of particles passing through 50µm sieves and 50% through 7 µm [16]. The authors as well mentioned that the marble powder had a high specific surface area, meaning that its addition as a mineral in mortars and concretes, especially in self-compacting concrete should impart more cohesiveness. Abdullah Anwar et al (2014) in their study analyzes that there is a continuous decrement in the compressive strength of concrete on partial replacement of cement with marble dust. It indicates the decrease in adhesive strength between the surface of marble powder and cement and core compressive strength is attained at 10% replacement of marble dust concrete [17] -[18]. Satish et al [19], worked extensively on the hardened properties of bituminous concrete with marble dust as filler. Fillers are fine aggregate material that passes 0.063mm sieve [20].

The advancement of concrete technology can reduce the consumption of natural resources. They have driven to focus on recovery and reuse of natural resources and find other options. The role of partial replacement of cement by marble dust powder or ceramic waste powder may reduce some cement production, thus brings down the demand for land area for describing resources and disposal of industrial waste too. The use of substitute materials may provide cost reduction, energy savings, arguably superior products, and fewer hazards in the surroundings. Ceramic waste powder or Marble dust powder is one of the most dynamic research areas that cover a number of subjects including civil engineering and building fabrics.

2. Experimental Materials

A. Cement

Commercially available Ordinary Portland Cement of 43 grades manufactured by the JP Cement Company confirming to IS 8112:1989 was used in the field [21] (Specification, Bureau of Indian Standards, New Delhi). The Physical Properties of OPC Cement are shown in Table 1.

Table 1: Physical Properties of Cement

Details	Normal Consistency (%)	Specific Gravity	Setting Time (min.)	
			Initial	Final
OPC (G-43)	26.75	3.05	80	190

B. Fine Aggregate

Fractions from 4.75 mm to 150 microns are termed as fine aggregate. Locally available river sand passed through 4.75mm IS sieve is applied as fine aggregate conforming to the requirements of IS 383:1970 [22]. The specific gravity of sand is 2.60 and fineness modulus is 3.30. The free and compacted bulk density values obtained are 1645 Kg/m^3 and 1780 Kg/m^3 and water absorption is 1.10%.

C. Coarse Aggregate

Fractions from 20 mm to 4.75 mm are used as coarse aggregate. The Coarse aggregate are obtained from a local quarry, conforming to IS 383:1970 is used. The coarse aggregate with a maximum size 20 mm having a specific gravity 2.70 and fineness modulus of 6.50. The free and compacted bulk density values obtained are 1600 Kg/m^3 and 1790 Kg/m^3 respectively, water absorption of 1.50%.

D. Marble Dust Powder

The Marble dust powder was collected from the locally available manufacturing unit in Lucknow, Uttar Pradesh, India. Specific gravity of marble dust powder is 2.64 and water absorption is 0.97%. It was sieved by IS-90 micron sieve before mixing in concrete. The Chemical properties were given in Table 2 and these properties are in reference to [Omar M.O. et al (2012)] [23]

ISSN 2348 – 7968

Figure 1: Marble Dust Powder
Source: Ceramic World, Lucknow, Uttar Pradesh

Table 2: Chemical Properties of Marble Dust Powder

S.No.	Materials	Ceramic Powder (%)
1.	Loss of Ignition (L.O.I)	43.63
2.	CaO	43.20
3.	Fe_2O_3	1.90
4.	Al_2O_3	2.50
5.	SiO_2	13.8
6.	MgO	2.70
7.	SO_3	0.07
8.	K_2O	0.60
9.	Na_2 O	0.90
10.	CL	0.03

Source: Omar M.O. et al (2012)

E. Ceramic Waste

Ceramic waste can be used in concrete to improve its strength and other durability factors. It is estimated that 15 to 30% wastes are produced of total raw material utilized. Ceramic waste can be applied as a partial replacement of cement or as a partial replacement of fine aggregate, sand as a supplemental add-on to achieve different properties of concrete. The ceramic waste was accumulated from the locally available manufacturing unit in Lucknow, Uttar Pradesh, India. The sample of the waste was collected and the same was made in dust form manually in Transportation Engineering Laboratory, CED, INTEGRAL UNIVERSITY, Lucknow. Specific gravity of ceramic waste powder is 2.30 and water absorption is 2.40%. The chemical properties were turned over in Table 3 with the submission of test method IS 3812:1998 [24].

Figure 2: Ceramic Waste Powder
Source: Ceramic World, Lucknow, Uttar Pradesh

Table 3: Chemical Properties of Ceramic Waste Powder

S.No.	Materials	Ceramic Powder (%)
1.	SiO_2	63.29
2.	Al_2O_3	18.29
3.	Fe_2O_3	4.32
4.	CaO	4.46
5.	K_2O	2.18
6.	Na_2 O	0.75
7.	MgO	0.72
8.	P_2O_5	0.16
9.	Mn_2O_3	0.05
10.	CL	0.005
11.	SO_3	0.10
12.	Loss of Ignition (L.O.I)	1.61

Source: Geo-Test House, Baroda, Gujarat

F. Water

Water is an important factor of concrete as it actually participates in the chemical reaction with cement. Portable water is employed in fusing of concrete.

ISSN 2348 – 7968

3. Economic Feasibility

The Economic Feasibility of materials is tabulated as below in Table 4.

Table 4: Cost of Materials

S.No.	Materials	Rate (Rs/Kg)
1.	Cement (OPC G-43)	8.00
2.	Fine Aggregate (Regional)	0.65
3.	Coarse Aggregate (Regional)	0.70
4.	Ceramic Waste Powder	3.00
5.	Marble Dust Powder	12.00

4. Nominal Proportions

The concrete mix is designed as per IS: 10262-1982 [25], IS: 456-2000 [26] for the normal concrete. The grade of concrete, which we adopted, is M20. The concrete mix proportion (cement: fine aggregate: coarse aggregate) is 1:1.5: 3 by volume and a water cement ratio of 0.50.

5. Experimental Methodology

The evaluation of Ceramic Waste Powder and Marble Dust Powder for use as a replacement of cement material begins with the concrete testing. The study is conducted to analyze the compressive strength of concrete when the base materials, i.e. Cement is replaced with ceramic waste powder and Marble Dust Powder respectively. Compressive strength tests were done on compression testing machine using cube samples. Three samples per batch were tested with the average strength values reported in this paper. The ceramic waste powder replacement was kept at 0%, 5%, 10%, 15%, 20%, 25%, 30%, 35%, 40%, 45%, 50% by weight of M-20 grade concrete. Similarly, marble dust powder replacement was also restrained at 0%, 5%, 10%, 15%, 20%, 25%, 30%, 35%, 40%, 45%, 50% by weight of M-20 grade concrete. In all total 66 cubes of OPC (150mm × 150mm × 150mm) were examined and results were analyzed after curing 28 days. Information obtained from the replacement is compared with data from a Conventional concrete.

6. Experimental Set-Up

Subsequently, on a detailed study we have obtained the following outcomes for the compression tests as shown in the Table 5 and Table 6

Table 5: Ceramic Waste Powder Replacement; Compressive Strength of Concrete (M 20)

S.No.	Specimen	Compressive Strength at 28 days (N/mm^2)
1.	Conventional Concrete	30.24
2.	5%	29.16
3.	10%	28.14
4.	15%	27.65
5.	20%	26.40
6.	25%	24.46
7.	30%	23.20
8.	35%	21.68
9.	40%	20.29
10.	45%	19.68
11.	50%	18.37

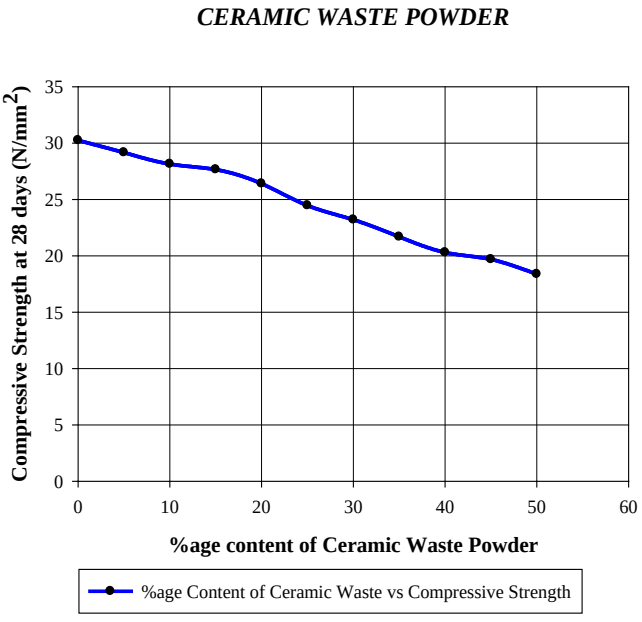

Fig.3: Percentage Replacement of Ceramic Waste Powder vs Compressive Strength (N/mm^2) of Concrete for M 20

ISSN 2348 – 7968

Table 6: Marble Dust Powder Replacement; Compressive Strength of Concrete (M 20)

S.No.	Specimen	Compressive Strength at 28 days (N/mm^2)
1.	Conventional Concrete	30.24
2.	5%	28.32
3.	10%	27.24
4.	15%	26.23
5.	20%	24.30
6.	25%	22.59
7.	30%	20.64
8.	35%	18.37
9.	40%	17.20
10.	45%	16.14
11.	50%	15.18

MARBLE DUST POWDER

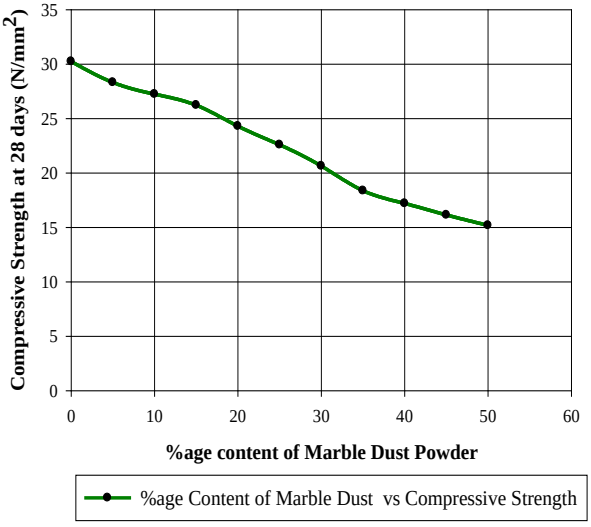

Fig.4: Percentage Replacement of Marble Dust Powder vs Compressive Strength (N/mm^2) of Concrete for M 20

COMPRESSIVE STRENGTH OF CONCRETE (M20)

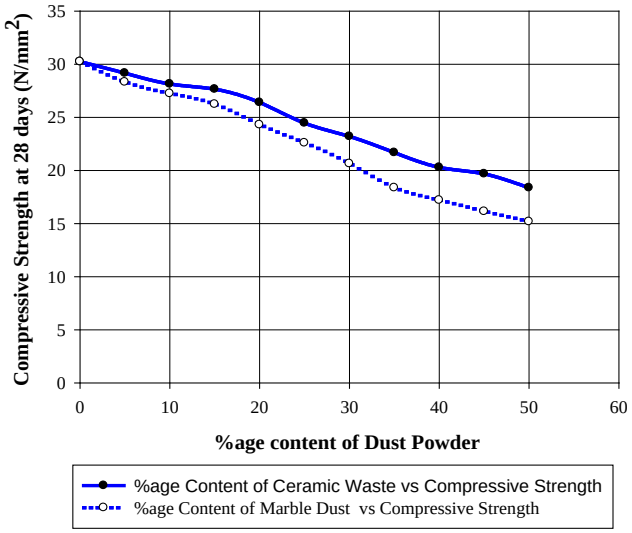

Fig.5: (MERGE GRAPH) Percentage Replacement of both Ceramic Waste and Marble Dust Powder vs Compressive Strength (N/mm^2) of Concrete for M 20

COMPRESSIVE STRENGTH OF CONCRETE (M20)

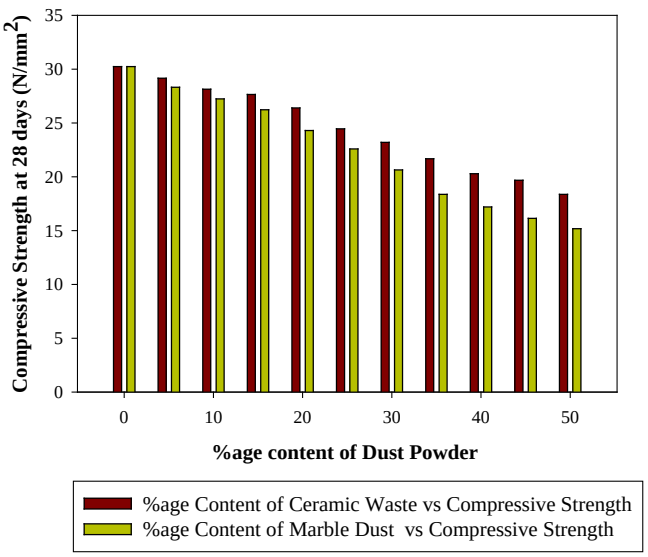

Fig.6: (BAR GRAPH) Percentage Replacement of both Ceramic Waste and Marble Dust Powder vs Compressive Strength (N/mm^2) of Concrete for M 20

ISSN 2348 – 7968

7. Results and Discussions

Experimental investigation is performed to determine the Compressive Strength of ceramic waste concrete and marble dust concrete on partial replacement of cement and also to compare the behavior of concrete for more fruitful outcome. At different proportions, varying strength of concrete was observed, which are measured in N/mm^2. The results obtained for 28-day compressive strength confirms the optimal percentage requirement for replacement of cement with Ceramic Waste Powder and Marble Dust Powder as shown in Fig. 5 (Merge Graph) and Fig. 6 (Bar Graph).

a. Effect of Ceramic Waste Powder on Compressive Strength:

Compressive strength is determined at 28 days after successful curing period. Due to higher part of silica oxide in ceramic waste its core compressive strength is attained at 30% replacement of ceramic waste concrete. By more than 30% of replacement, the compressive strength is decreasing, hence more research on it is preferred. On further replacement its compressive strength is decreased. The results obtained confirms the optimal percentage requirement for replacement of cement with Ceramic Waste Powder as shown in Fig. 3

b. Effect of Marble Dust Powder on Compressive Strength:

Compressive strength is determined at 28 days after successful curing period. Due to lower percentage of silica oxide in marble dust powder its compressive strength decreases continuously. The rate of fall shows the reduction in adhesive strength between the surface of marble powder and cement. Its core compressive strength is attained at 20% replacement of marble dust concrete. On further replacement of Cement with marble dust powder, decreases the Compressive Strength. The results obtained confirms the optimal percentage requirement for replacement of cement with Marble Dust Powder as shown in Fig. 4

8. Conclusion

The purpose of this research is to finding and comparing out the characteristic strength of M20 grade ceramic waste powder concrete and marble dust powder concrete at the water cement ratio of 0.50 for better fruitful replacement. Based on experimental investigations concerning the compressive strength of concrete, the following observations are drawn:

a) As compared to conventional concrete, on addition of ceramic waste powder its characteristic strength is decreased. So the ceramic waste powder has been replaced by up to 30% by weight of cement without affecting the characteristic strength of M20 grade concrete. On further replacement of cement with ceramic waste powder decreases the compressive strength. (Fig. 5 and 6)

b) As compare to conventional concrete, on addition of marble dust powder its characteristic strength is decreased. So the marble dust powder has been replaced by up to 20% by weight of cement without affecting the characteristic strength of M20 grade concrete. On further replacement of cement with marble dust powder decreases the compressive strength. (Fig. 5 and 6)

c) Concrete on 30% replacement of Cement with Ceramic Waste Powder, Compressive Strength obtained is 23.20 N/mm^2 whereas on 20% replacement of Cement with Marble Dust Powder, Compressive Strength obtained is 24.30 N/mm^2. Consequently, ceramic waste becomes more economical as compare to marble dust powder without compromising concrete strength than the standard concrete. So causing the replacement both technically and economically feasible and viable (Table 4).

d) Utilization of ceramic waste or marble dust and its application for the sustainable development of the construction industry is the most effective solution and also speak the high value application of such waste.

e) It is the possible alternative solution of safe disposal of the Ceramic waste powder and Marble dust powder thus stepping into a realm of solving the environmental pollution by cement production; being one of the primary objectives of Civil Engineers.

References

[1] Nataraj, M.C., Nagaraj, T.S., Reddy, A., “proportioning concrete mixes with quarry wastes” Cem Conct Aggregate 23(2): 81-88, 2001.

[2] Hanifi Binici, “Effect of crushed ceramic and basaltic pumice as fine aggregates on concrete mortars properties” Construction and Building Materials 21 1191-1197, 2007.

ISSN 2348 – 7968

[3] C. Medina, M.I, Sanchez, M. Frias, "Reuse of sanitary waste as coarse aggregate in eco- efficient concretes", cement and concrete composites 34, 48-54, 2012.
[4] Asokan Pappu, Mohini S., Shyam R.A., "Solid waste generation in India and their recycling potential in building material", building and environment, 42, 2311-2320, 2007.
[5] Pincha Torkittikul, Arnon Chaipanich, "Utilization of ceramic waste as fine aggregate within portland cement and fly ash concretes", cement and concrete composites 32, 440-449,2010.
[6] RM. Senthamarai, P. Devadas Manoharan, "Concrete with ceramic waste aggregate" Cement & Concrete Composites, 27,910-913, 2005.
[7] Nuran Ay, Mevlut Unal "The use of waste ceramic tile in cement production", Cement and Concrete Research 30 497-499, 2000.
[8] Guerra, I.; Vivar, I.; Llamas, B.; Juan, A.; Morán, J. M. Eco-efficient concretes: The effects os using recycled ceramic material from sanitary installations on the mechanical properties of concrete. Waste Management, 29 (2),2009).
[9] Koyuncu, H.; Guney, Y.; Yilmaz, G.; Koyuncu, S.; Bakis, R.Utilization of ceramic wastes in the construction sector. Key Engineering Materials, 264-268, 2004.
[10] Senthamarai, RM.; Devadas Manhoharan, P. Concrete with ceramic waste aggregate. Cement and Concrete Composites, 27(910) 910-913, 2005.
[11] Marble Formation, Characteristics and Application. http://www.phsyicalgeography.netfundamental/109.htm
[12] Siddharth Pareek. Gainful Utilization of Marble Waste. An effort towards protection of Ecology Environment" and http.//www.cdos-india.com/papers2001, accessed on 22-08-2007.
[13] Binici H, Kalpan H, Yilmaz S. Influence of marble and limestone dusts as additive on some mechanical properties of concrete. *Scientific Research and Essay* 2007, 2(9), 372-379.
[14] Stone. Cited in Marbleandmore.com (online reference material), 2000, accessed on 15-09-2007.
[15] Kearey Philip. Dictionary of Geology, Penguin Group, London and New York, 2001, 163
[16] Valeria Corinaldesi, Giacomo Moriconi, and Tarun R. Nick, (2005), "characteristics of marble powder for its use of mortar and concrete", NMET/ACI International symposium on sustainable development of cement and concrete, October 57,Toronto, Canada.
[17] Anwar, Abdullah, et al. "Study of Compressive Strength of Concrete by Partial Replacement of Cement with Marble Dust Powder." *ISSN* (Print) (2014): 2321-5747, International Journal on Mechanical Engineering and Research (IJMER), Vol.2, Issue 3, pp 01-04, 2014.
[18] Abdullah A, Sabih A, Juned A, Aqeel A, Ashraf S, (2014), "Study of Compressive Strength of Concrete by Partial Replacement of Cement with high volume fly ash ",International Journal of Current Engineering and Technology (IJCET), Vol.4, No. 6, pp 4162-4166, 2014.
[19] Satish C, and Choudhary, R. Performance Characteristics of Bituminous Concrete with Industrial Wastes as Filler. Journal of Materials in Civil Engineering, vol. 25, No 11, pp 1666 – 1673, 2013.
[20] Houari H. Hebhoub H; Aoun H; and Belachia M. Use of Waste Marble aggregates in concrete. Construction Build Mater 2011; 25: 1167-71
[21] IS: 8112-1989, 43 Grade Ordinary Portland cement—Specification, Bureau of Indian Standards, New Delhi.
[22] BIS 383: 1970 Course and fine aggregate from natural sources for concrete 9th Revision, BIS, New Delhi, 1970.
[23] Omar M.O., Ghada D. Abd El., Mohamed A.S and Hassan A.M (2012) Influence of limestone waste as partial replacement material for sand and marble powder in concrete properties *HBRC Journal* 8, 193–203
[24] IS: 3812: 1998 specifications for fly ash for use as pozzolana and admixture, 4th Revision, BIS, New Delhi, 2009.
[25] IS: 10262-1982, Recommended Guidelines for Concrete Mix Design—Bureau of Indian Standards, New Delhi.
[26] IS: 456-2000, Plain and Reinforced Concrete—Code of Practice—Bureau of Indian Standards, New Delhi.

Abdullah Anwar was born in 1988 in Gorakhpur city, Uttar Pradesh. He received his Bachelor of Technology degree in Civil Engineering from U.P.T.U, Lucknow, in 2012. At present he is a final year student of Master's Degree in Structural Engineering. He joined Integral University, Lucknow as a faculty (Lecturer) in Department of Civil Engineering. He has Papers Published in International Journals/Conferences. He is also an Associate Member of Institution of Engineer's.

Sabih Ahmad was born in 1971 in Aligarh city, Uttar Pradesh. He received his B.Sc Engineering (Civil) from A.M.U, in 1994. In 2002 he received his Master's Degree in Structural Engineering from A.M.U, Aligarh and pursuing Ph.D from Integral University, Lucknow. He has a vide experience in teaching, research at UG and PG levels. Presently he is Associate Professor and Head of the Department of Civil Engineering at Integral University, Lucknow He has authored numerous research papers in National and International Journals/Conferences. He is also a Member of Institution of Engineer's.

S.M. Ashraf Husain was born in 1970 in Kanpur city, Uttar Pradesh. He completed his Diploma Engineering (Civil) in 1990. He worked over a decade in the construction industry; mainly in Quality Control at International Level was born in 1988 in Gorakhpur city, Uttar Pradesh. He received his Bachelor of Technology degree in Civil Engineering from Integral University, Lucknow, in 2011. In 2014 he received his Master's Degree in Structural Engineering from Integral University, Lucknow. Presently he is Assistant Professor, in Department of Civil Engineering at Integral University, Lucknow. He has Papers Published in International Journals/Conferences. He is also an Associate Member of Institution of Engineer's.

ISSN 2348 – 7968

Syed Aqeel Ahmad was born in 1975 in Lucknow city, Uttar Pradesh. He received his B.Sc Engineering (Civil) from Jamia Millia Islamia, New Delhi in 1996. In 1999 he received his Master's Degree in Transport Planning from School of Planning and Architecture, New Delhi and pursuing Ph.D from Integral University, Lucknow. He owns a vide professional experience and worked as Deputy Director (Technical) in the Ministry of Urban Development, Govt. of India, New Delhi. Presently he is Associate Professor, in Department of Civil Engineering at Integral University, Lucknow. He has authored numerous research papers in National and International Journals/Conferences. He is also a Member of Indian Road Congress (IRC), Institute of Town Planning of India (ITPI), Institute of Urban Transport (IUT), Institute of Rail Transport (IRT), American Society of Civil Engineer's (ASCE).