International Journal of Scientific Research & Engineering Trends
Volume 11, Issue 4, July-Aug-2025, ISSN (Online): 2395-566X

# Experimental Study on the Properties of Concrete Using Marble Powder and Steel Fibres as Partial Cement Replacement

**Deepak Kumar Mishra**
Department Of Civil Engineering radha Raman Engineering College Bhopal

**Abstract: Concrete, a fundamental material in construction, is increasingly being modified to incorporate sustainable alternatives that enhance performance while minimizing environmental impact. This study investigates the effects of partially replacing cement with marble powder and adding steel fibres in varying proportions (0%, 0.5%, 1%, 1.5%, and 2.0%) on the mechanical properties of M25 grade concrete. Results show that a mix containing 15% marble powder and 1% steel fibre achieves optimal compressive, split tensile, and flexural strength at 28 days. The marble powder improves workability due to its smooth texture and spherical shape, while the addition of steel fibre, though reducing workability, enhances bonding and overall strength. The findings suggest that the combination of marble powder and steel fibres can be effectively used in structural applications such as multistoried buildings and bridges. A recommended optimal mix of 15% marble powder and 1% steel fibre offers the best performance, though further long-term studies are advised to assess durability and field performance.**

**Keywords : Include Keywords: Concrete, Marble powder, Steel fiber, Compressive Strength, Tensile Strength.**

## I. INTRODUCTION

In today's time, concrete is the most important material in the construction sector, concrete affects the entire cost of civil engineering structures and buildings on a large scale. Concrete's global environmental impact is a complex mixture of negative effects. Worldwide, by-products from a variety of industries pose a serious threat to the environment. Concrete researchers have focused a lot of attention on waste marble powder and Fibers, one of the many by-products produced by the industries. Fibers are of small pieces of reinforcing material that have specific dimensional properties. The aspect ratio of a fiber is its most important characteristic. The most crucial feature of a fiber is its aspect ratio. The type of fiber has a significant impact on the characteristics of fiber-reinforced concrete Fibers act as a secondary reinforcement material and crack arrester.

## II. LITERATURE REVIEW

Hasan Kazi Shahariar (2024) One noteworthy technique is Steel Fiber-Reinforced Concrete (SFRC), in which concrete is mixed with short steel fibers. The mechanical behavior of recycled steel fibers in concrete was examined in this study and contrasted with that of regular concrete. This study investigates the use of recycled steel fibers in concrete, were analyzed for their mechanical behavior in comparison to conventional concrete. Laboratory tests revealed that an optimal dosage of 1–1.5% of recycled steel fibers with an aspect ratio around 75 improves concrete strength. After casting and testing concrete cylinders and beams, it was observed that strength initially increased up to 1.5% fiber dosage but then plateaued or decreased. This reduction in strength beyond 1.5% may be attributed to decreased concrete cohesiveness and disturbance introduced by the recycled steel fibers. Moriconi et al. (2010) carried out investigation on characterization of marble powder for its use in mortar and concrete. In this paper, they established that with the replacement of 10% of marble powder with sand gives a maximum compressive strength at about the same workability, comparable to that of the reference mixture after 28 days of curing. Mixtures were evaluated based upon cement or sand substitution by the marble powder.

## III. EXPERIMENTAL PROGRAMME

The primary goal of this dissertation project is to investigate the strength properties of concrete that is made by first replacing cement with waste marble powder and then adding steel fibers in an optimized percentage of waste marble powder with a variable percentage. Compressive strength, splitting tensile strength, and flexural strength were the primary engineering attributes assessed. The following describes the materials used to cast fiber concrete samples as well as the test results.

Cement, coarse and fine aggregates, water, leftover marble powder, and steel fiber were the materials used in this dissertation. To reduce variation in results, only one type of cement is used in the concrete mix. Gradation tests are used to select aggregates that are free of impurities, and during the course of this study, specific standards were met.

**Concrete Workability Test by Slump Cone Method**

The slump test, which gauges the consistency of concrete by measuring its workability, is a valuable tool for identifying differences in the homogeneity of a mixture of specified nominal proportions. ASTM C 143 90A, BS 1881 Part 102:1983, and IS: 456 (2000) all recommend the slump test. The slump test mold is a cone frustum that is 300 mm (12 in) high. With the smaller opening at the top, it is set on a level surface and filled with three layers of concrete. With the help of handles or foot rests brazed to the mold, each layer is tamped 25 times with a standard 16mm (5 inch) diameter steel rod, rounded at the end, and the top surface is cut off using a saw while the base is rolled. The test gets its name because the unsupported concrete will slump as soon as the cone is gradually raised after filling. The decrease in the height of the slumped concrete is called slump and is measured to the nearest 5mm.

**Compressive Strength of Concrete**

At the age of 28 days, cube specimens measuring 150 mm by 150 mm by 150 mm were removed from the curing tank and tested right away after being removed from the water (while still in the wet condition). The specimens were tested after the surface water was removed. When tested, the cube's position was perpendicular to its cast position. The compressive strength was determined by applying the load gradually and without shock until the specimen failed.

**Split Tensile Strength of Concrete**

The split tensile strength of concrete is determined by casting cylinders of size 150 mm X 300 mm. The cylinders were tested by placing them uniformly. Specimens were taken out from curing tank at age of 28 days of moist curing and tested after surface water dipped down from specimens. This test was performed on Universal Testing Machine (UTM).

**Flexural Strength**

The flexural strength test was done using Third point loading (flexural strength) machine, in compliance to IS 516:1959. Samples were taken randomly from tank at the specified age and were checked for cleanliness. At the age of 7 days, 3 Beams were removed from the tank. Each beam was then positioned in the third point loading machine with resting on ends on two rollers. The maximum loading rate which was applied on specimen was 180 kg/m. These procedures were applied onto the remaining 2 samples and the average reading was taken as the Flexural strength at the age of 7 days. This test was performed again at the concrete age of 14, and 28 days.

**Calculating How Much Fiber Should Be Added To The Mixture:**

The fibre content is taken as 0.5 percent by volume of concrete mix. Therefore 0.5% by volume
= (0.005×unit weight of fibre/ 0.995×unit weight of concrete)×100= % by weight We have, Unit weight of fibre = 7864 kg/m3
Unit weight of concrete = 2400 kg/m3 0.5% by volume
= (0.005×7864/ 0.995×2400) × 100 = 1.6465% by weight 0.5% fibre by volume
= (% by weight/100) ×unit weight of concrete in kg/m3 0.5% fibre by volume
1.6465/100) ×2400= 39.516 kg/m3 = 40 kg/m3 (approx.)
0.5 % Fibre content = 39.516 kg/m3
For 1.0 % Fibre content = 79 kg/m3
For 1.5 % Fibre content = 118.6 kg/m3
For 2.0 % Fibre content = 158 kg/m3

**Specimens Prepared Details**

A. 150mm X 150mm X 150mm Cube Specimens for Compressive Strength.
B. 150mm X 300mm Cylindrical Specimen for Split Tensile Strength.
C. 100mm x 100mm x 500mm Beam specimens are used for Flexural Strength test.

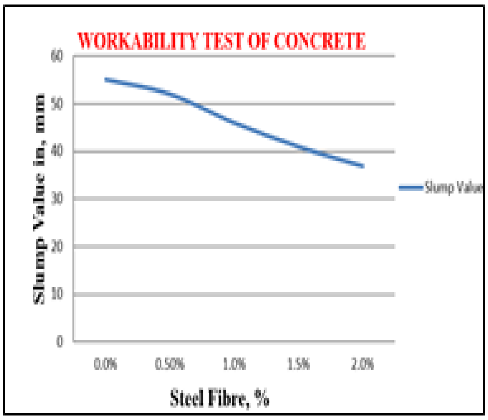
Compared to regular concrete, each mix with varying percentages of steel fiber and marble powder has a different percentage of cement substituted, i.e. controlled Each case has the following number of cast specimens.
Workability of concrete test like slump cone test.
Engineering properties like Compressive, Split tensile and Flexural strength test.

## IV. FIGURES AND TABLES

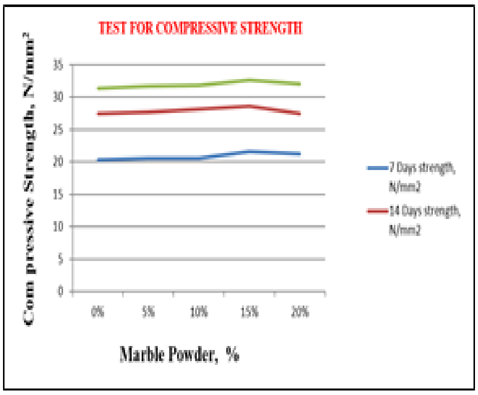
Cement, coarse and fine aggregates, water, leftover marble powder, and steel fiber were the materials used in this dissertation. To reduce variation in results, only one type of cement is used in the concrete mix. Gradation tests are used to select aggregates that are free of impurities, and during the course of this study, specific standards were met.

Fig 4.1: Particle size analysis test for aggregates.

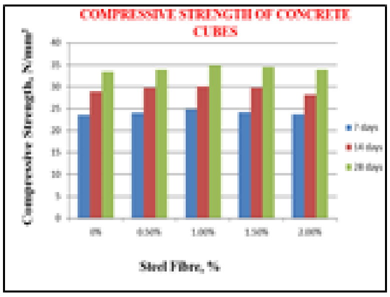
Graphs:



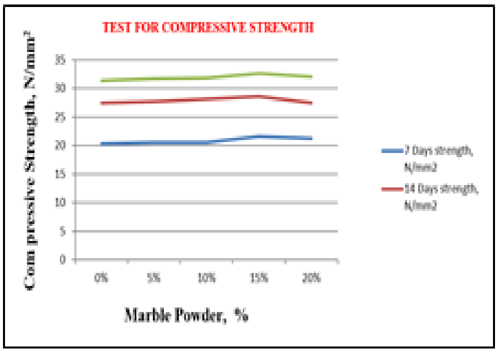

Graph 4.1: Workability test of concrete by slump cone method with different percentage of steel fibre.



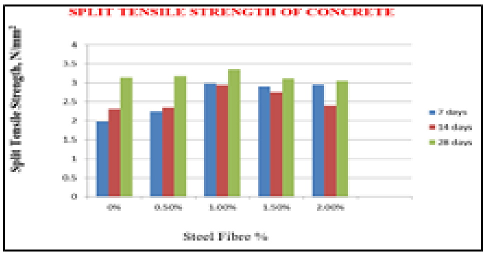

Graph 4.2: Compressive Strength testing of concrete with various % marble dusts.



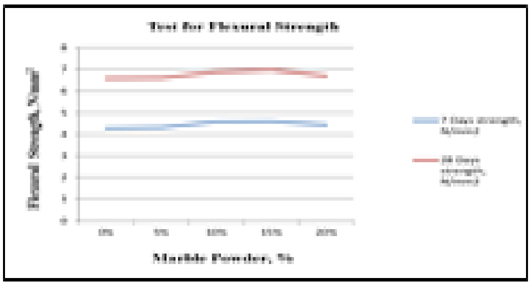

Graph 4.3: Compressive Strength variation of each mix with 15 % of marble powder & different % of Steel fibre.



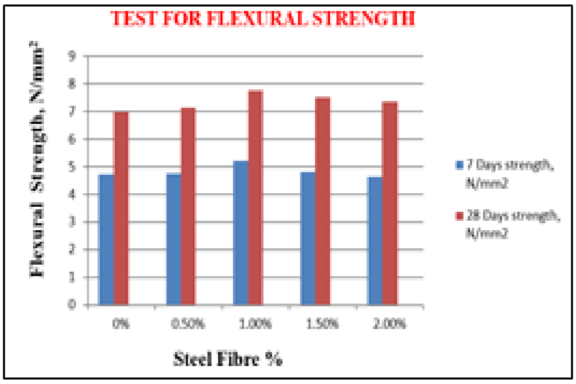

Graph 4.4: Split Tensile Strength testing of concrete cylinders with various marble powder %.



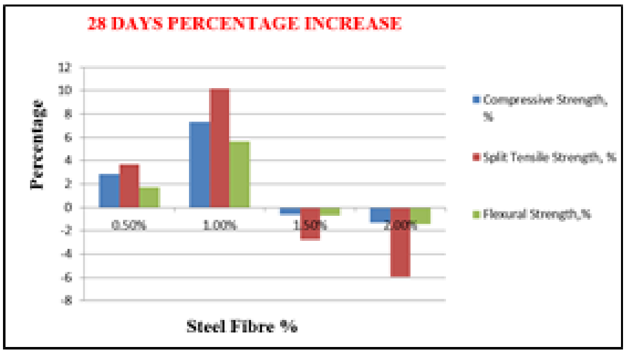

Graph 4.5: Test results of split tensile strength of different mix with 15% of marble powder & variable % of Steel fibre.




Graph 4.6: Flexural Strength testing of concrete Beam with various marble powder %.




Graph 4.7: Flexural Strength variation of each mix with 15 % marble powder & different % Steel fibre.




Graph 4.8: 28 Days percentage increase of strength with 15% of marble powder & different % of Steel fibre.

Table 4.1: Workability test of concrete by slump cone method.

| S.No | Marble Dust (15%) + Steel Fiber % | Weight of Marble Dust in Mix (Kg/cum) | Weight of Steel Fibre in Mix (Kg/cum) | Slump Value, mm | S.No | Marble Dust (15%) + Steel Fiber % |
|---|---|---|---|---|---|---|
| 1 | 0 | 62.60 | 00 | 53 | 1 | 0 |
| 2 | 0.5 | | 40 | 52 | 2 | 0.5 |
| 3 | 1.0 | | 80 | 45 | 3 | 1.0 |
| 4 | 1.5 | | 120 | 41 | 4 | 1.5 |
| 5 | 2.0 | | 160 | 38 | 5 | 2.0 |

Table 4.2: Details of Compressive Strength test with various % of marble dust

| S. No | Cube Sample name | Marble powder, % | 7 Days strength, N/mm$^2$ | 14 Days strength, N/mm$^2$ | 28 Days strength, N/mm$^2$ |
|---|---|---|---|---|---|
| | | | Average of 3 samples | | |
| 1 | A - 0 | 0 | 20.36 | 27.48 | 31.33 |
| 2 | A - 5 | 5 | 20.51 | 27.65 | 31.77 |
| 3 | A - 10 | 10 | 20.58 | 28.10 | 31.89 |
| 4 | A - 15 | 15 | 21.60 | 28.57 | 32.64 |
| 5 | A – 20 | 20 | 21.23 | 27.44 | 32.1 |

Table 4.3: Test results of compressive strength of different mix with different percentage of 15% marble powder & Steel fibre.

| S.No | Marble powder (15%) + Steel Fiber % | Average Compressive Strength (N/mm$^2$) | | |
|---|---|---|---|---|
| | | 7 days | 14 days | 28 days |
| 1 | 0 % | 23.6 | 28.89 | 33.5 |
| 2 | 0.5% | 24.1 | 29.77 | 33.9 |
| 3 | 1.0% | 24.9 | 30.10 | 35 |
| 4 | 1.5% | 24.2 | 29.74 | 34.5 |
| 5 | 2.0% | 23.7 | 28.20 | 33.89 |

Table 4.4: Details of Split Tensile Strength test with different % of marble powder

| S.No | Cylindrical Sample name | Marble powder, % | 7 Days strength, N/mm$^2$ | 14 Days strength, N/mm$^2$ | 28 Days strength, N/mm$^2$ |
|---|---|---|---|---|---|
| | | | Average of 3 samples | | |
| 1 | AA - 00 | 0 | 1.95 | 1.98 | 3.21 |
| 2 | AA - 05 | 5 | 2.06 | 2.26 | 3.26 |

| | | | | | |
|---|---|---|---|---|---|
| 3 | AA - 10 | 10 | 2.09 | 2.39 | 3.44 |
| 4 | AA - 15 | 15 | 2.18 | 2.44 | 3.61 |
| 5 | AA - 20 | 20 | 2.08 | 2.13 | 3.41 |

Table 4.5: Split tensile strength of different mix with 15% of marble powder & different % Steel fibre

| S.No | Marble powder (15%) + Steel Fiber % | Average Split Tensile Strength (N/mm²) | | |
|---|---|---|---|---|
| | | 7 days | 14 days | 28 days |
| 1 | 0 % (Control) | 1.98 | 2.32 | 3.14 |
| 2 | 0.5% | 2.24 | 2.36 | 3.17 |
| 3 | 1.0% | 2.99 | 2.95 | 3.36 |
| 4 | 1.5% | 2.90 | 2.75 | 3.11 |
| 5 | 2.0% | 2.96 | 2.41 | 3.06 |

Table 4.6: Details of Flexural Strength test with different % of marble powder

| | Beam | | 7 Days strength, $N/mm^2$ | 28 Days strength, $N/mm^2$ |
|---|---|---|---|---|
| S.No | Sample name | Marble powder, % | Average of 3 samples | |
| 1 | B0 | 0 | 4.28 | 6.59 |
| 2 | B 5 | 5 | 4.32 | 6.62 |
| 3 | B 10 | 10 | 4.58 | 6.88 |
| 4 | B 15 | 15 | 4.61 | 6.98 |
| 5 | B 20 | 20 | 4.44 | 6.71 |

Table 4.7: Flexural strength test results of each mix with 15% of marble powder & Steel fibre.

| S.No | Marble powder (15%) + Steel Fiber % | 7 Days strength, $N/mm^2$ | 28 Days strength, $N/mm^2$ |
|---|---|---|---|
| | | Average of 3 Samples | |
| 1 | 0 % (Control) | 4.72 | 6.99 |
| 2 | 0.5% | 4.76 | 7.13 |
| 3 | 1.0% | 5.21 | 7.76 |
| 4 | 1.5% | 4.80 | 7.51 |
| 5 | 2.0% | 4.66 | 7.35 |

Table 4.8: 28 Days percentage increase of strength with different percentage of marble powder & Steel fibre %.

| S.No | Marble powder (15%) + Steel Fiber % | Average | | |
|---|---|---|---|---|
| | | Compressive Strength, % | Split Tensile Strength, % | Flexural Strength,% |
| 1 | 0.5% | 2.86 | 3.,67 | 1.71 |
| 2 | 1.0% | 7.32 | 10.15 | 5.62 |
| 3 | 1.5% | -0.62 | -2.78 | -0.69 |
| 4 | 2.0% | -1.34 | -5.94 | -1.46 |

## V. CONCLUSIONS

**From the experimental results, the following conclusion can be drawn:**

**Workability**

Test results shows that the workability increases when percentage of waste marble powder for M25 grade of concrete increased up to 20% replacement by cement. The workability increase due to greater surface area contact, smooth texture of marble powder, and spherical shape of marble powder particles. After addition of steel fibre into the concrete, it significantly decreases the workability due to the reinforcing effects of steel fibres which makes better bond between concrete substrates

**Strength Characteristics**
The enhancement in different strengths is observed with the addition of marble powder and Steel fibres in the plain concrete. However, maximum gain in strength of concrete is depending upon the amount of fibre content to be mixed.

The research is done first on the marble powder incorporation in replacement with cement, so it was observed that 15 % marble powder is optimum for replacement.

On the basis of those result second lot was prepared adding different percentage of steel fibres, so from this results obtained shows that 1% steel fibre in addition with 15 % marble powder shows better results in all the aspects.Concrete mix with 15 percent marble dust as replacement of cement is the optimum level as it has been observed to show a significant increase in compressive strength at 28 days when compared with nominal mix.

Concrete mixes when reinforced with steel fibre show an increased compressive strength as compared to nominal mix. The split tensile strength also tends to increase with increase percentages of steel fibres in the mix. The flexure strength also increases with the different percentages of steel fibres, as trend similar to increase in split tensile strength and compressive strength.

The most important contribution of fiber reinforcement in concrete is not to strength but to the flexural stiffness of the material.Maximum gain in strength of concrete is found to depend upon the amount of fibre content. The optimum fibre content to impart maximum gain in various strengths varies with type of the strengths.

**Recommendation**
The partial replacement of Marble powder-Steel fibre in concrete results in improvement of compressive strength, split tensile and Flexural strength. On the basis of these results, modified concrete made using Marble powder -Steel fibre may be suggested to be used with various types of concrete structures in India especially for the design of multistoried structures and bridges.

Even though for the mixes rich in cement, the dosage of Marble powder -Steel fibre needs to be adjusted to maintain required workability of concrete. It is suggested that percentage of Marble powder -Steel fibre content between 15% and 1% respectively, to be used in order to get the maximum strength.

It is also recommended that this study to be done in a longer period of time to see the effects of Marble powder -Steel fibre use for construction, it is necessary that the material used is long lasting.

## REFERENCES

1. Ying-tao Wang “Behaviour of reinforced concrete beams utilising waste marble owder subjected to impact loads” oshan University, Foshan 528000, Construction and Building Materials Volume 472, 18 April 2025, 140969.
2. Kazi Shahariar Hasan “Investigating The Potential of Recycled Steel Fibers in Concrete” Ahsanullah University of Science and Technology, Research Square in 2024 DOI:10.21203/rs.3.rs-4478706/v1.
3. “I.S: 516-1959”. Method of test for strength of concrete, Bureau of Indian Standards, New Delhi, 1959.
4. “IS: 8112-1989”. Specifications for 43-Grade Portland cement, Bureau of Indian Standards, and New Delhi, India.
5. IS: 1199-1959”. Indian Standards Methods of Sampling and Analysis of Concrete, Bureau of Indian Standards, New Delhi, India.
6. “I.S:2386 (Part I, IV, VI)-1988”. Indian standard Method of test for aggregate for concrte, Bureau of Indian Standards, Reaffirmed, New Delhi, 2000.
7. IS: 383- 1970,Indian standard of specification for coarse and fine aggregates from natural sources for concrete(second revision).
8. I.S: 10262-198”. Recommended guidelines for concrete mix design, Bureau of Indian Standards, reaffirmed, New Delhi 1999 and IS: 456:2000 Indian standard recommended guidelines for concrete mix design.
9. ACI committee 544, 3R-08, 2008. “Guide for specifying, proportioning, and production of fibre reinforced concrete.” American concrete institute, Farmington hills, USA.
10. Er: Raj.p.singh kushwah, Prof (Dr.) Ishwar Chand Sharma, Prof (Dr.) PBL Chaurasia(2015) Utilization of “Marble Slurry” In Cement Concrete Replacing Fine Aggregate.American Journal of Engineering Research (AJER) e- ISSN : 2320-0847 p-ISSN : 2320-0936Volume-04, Issue-1, pp-55-58.
11. Noha M. Soliman, 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 Vol.3, No.5 (December 2013).
12. Prof. Veena G. Pathan, Prof. Md. Gulfam Pathan, Feasibility and need of use of waste marble powder in

concrete production IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE).

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, ISSN: 372-379, Vol 2, 2012. 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, Vol.31, pp. 251–257, 2012.
14. Prof. P.A. Shirule, Ataur Rahman, Rakesh D. Gupta “Partial Replacement of Cement with Marble Dust Powder”, IJAERS,Vol. I,Issue III,April-June, 2012/175-177E-ISSN 2249–8974.
15. Osman Gencela, CengizOzelb, FuatKoksalc, ErtugrulErdogmusd, Gonzalo Martínez-Barrerae, WitoldBrostow. “Properties of concrete paving blocks made with waste marble.” Journal of Cleaner Production 21 (2012) 62-70.
16. Soulioti, D. V., et al. "Effects of Fibre Geometry and Volume Fraction on the Flexural Behaviour of Steel-Fibre Reinforced Concrete." Strain 47.s1 (2011): e535-e541.
17. Veronez M, Calmon J L, Dos S S B and Andrade M A S. “Metakaolin & Silica Fume HPC Made with Different Kinds of Superplasticizers: A Comparison of Physical and Mechanical Properties Development.” Proc 2nd International Fib Congr, Naples, Italy (2006), Vol 13, Pp 1-9.
18. A.M. Shende, A.M. Pande, M. Gulfam Pathan., “Experimental Study on Steel Fiber Reinforced Concrete for M - 40 Grade”, International Refereed Journal of Engineering and Science (IRJES) ISSN (Online) 2319-183X, (Print) 2319- 1821 Volume 1, Issue 1 September 2012, 43-48.
19. Rui D. Neves and Joao C. O. Fernandes de Almeida, 2005. “Compressive behaviour of steel fibre reinforced concrete”, structural concrete. 2005-06. No. 1.
20. Baboo Rai, Khan Naushad H , Abhishek Kr, Tabin Rushad S, Duggal S.K, The effect of using marble powder and granules as constituents of fines in mortar or concrete.