EXPERIMENTAL STUDY OF WASTE MARBLE POWDER AND STEEL FIBRES FOR CEMENT CONCRETE MIXES

Birbal Kumar[1], Prof. Kapil Soni [2]
[1]Scholar M.Tech (CTM), [2]HoD,
Department of Civil Engineering, University Institute of Technology, RNTU Bhopal (M.P).

ABSTRACT: Concrete is currently one of the most widely used construction material. In contemporary concrete industry, there is a need of sustainable improvement because of large demand of cement, so concrete industry should be utilized the industrial and farming waste components. After scrutinized past years report, cement produce large amount of carbon dioxide gas released in environment during the production of cement that is consequences for global warming and greenhouse effect, it is not denying that cement is the main ingredient in the production of concrete. For reducing environmental problems and cement demand, we were utilized Waste marble powder and steel fibers in this study and analyzed the strength of concrete. To counter the tensile limitation, concrete is ordinarily assorted with steel reinforcement. The tensile reinforcement compensates for the lack of tensile ability, increased brittleness and decreased strain capacity. To achieve this objective we are partially replacing the cement with waste marble powder as partial replacement of cement incorporating with steel fibers. In this research, steel binding wires were used as steel fibers which are locally available at very cheap cost. Steel fibers were added in different percentage i.e. 0.5 %, 1 %, 1.5 % and 2 % along with control samples (0% Fibers) with addition with waste marble powder.

Keywords: Concrete, Waste Materials, Marble powder, Steel Wires, Durability, Mechanical Properties.

I. INTRODUCTION

The word concrete comes from the Latin word "concretus" (meaning compact or condensed), the perfect passive participle of "concrescere", from "con-" (together) and "crescere (to grow). During the Roman Empire, roman concrete (or opus caementicium) was made from quicklime, pozzolana and an aggregate of pumice. Concrete is a relatively brittle material, when subjected to normal stresses and tensile loads. Tensile strength of concrete is approximately one tenth of its compressive strength. As a result for this individuality, plain concrete members could not support loads and tensile stresses that occurred, on concrete structures. Concrete members are reinforced with continuous reinforcing bars to withstand tensile stresses and compensate for the lack of ductility and strength. The addition of steel reinforcement considerably increases the strength of concrete, and consequences in concrete with homogenous tensile properties; however the development of micro cracks in concrete structures must be checked. The introduction of fibers is generally taken as a solution to develop concrete in view of enhancing its flexural and tensile strength.

II. WASTE MARBLE POWDER

Marble powder is one of the waste produces in marble industry. It is obtained during the processes of sawing and shaping. It is collected as slurry near the dumpsite of the industry. It mixes with the water and makes it unfit for reuse. Due to the presence of heavy metals it affects the environment and also the human health. Marble as a building material especially in palaces and monuments has been in use for ages. However the use is limited as stone bricks in wall or arches or as lining slabs in walls, roofs or floors, leaving its wastage at quarry or at the sizing industry generally unattended for use in the building industry itself as filler or plasticizer in mortar or concrete.

III. FIBERS IN CONCRETE

Fibers can be defined as a small piece of reinforcing material possessing certain dimensional characteristics. The most significant parameter describing a fiber is its Aspect ratio. “Aspect ratio” is the span of fiber divided by an equivalent diameter of the fiber. The properties of fiber reinforced concrete are very much affected by the type of fiber. Fibers are secondary reinforcement material and acts as crack arrester. Prevention of dissemination of cracks originating from internal flaws can result in improvements in static and dynamic properties of the medium. The concept that post cracking of concrete can be improved by the inclusion of fiber. There has been a wave of interest in fiber reinforced concrete and several interesting experiments have been carried out. Fibers are taken as a new form of binder that combines Portland cement in the bonding with cement matrices. Fibers are generally discontinuous, indiscriminately distributed throughout the cements matrices. numerous kinds of fibers such as steel, fibrillated polypropylene, nylon asbestos, coir, jute, sisal, glass, and carbon have been tried and these are available in a variety of shapes, sizes, and thickness Fibers can be broadly be classified into two groups as Low Modulus High Elongation Fibers and High Modulus Fibers.

PROBLEM STATEMENT

Construction field is growing very intensely these days; hence there is a great demand for improvement in construction materials. Builders need to be assured that their structure can last for a long time. Our current production of normal concrete is unsatisfactory to support the growth and need of the construction industry especially in the high rise building involving compound attack. Therefore, a need for durable concrete is there while maintaining its engineering properties.

IV. EXPERIMENTAL PROGRAMME

The main objective of this dissertation work is to study strength characteristics of concrete with replacement of cement with waste marble powder firstly and incorporation of Steel fibres in optimized % of waste marble powder with variable percentage .The main engineering properties evaluated was compressive strength, splitting tensile strength and flexural strength. The materials used for casting fibre concrete samples along with the tested results are described as under.

CONCRETE MIX PREPRATION

The mix was prepared as nominal mix in a ratio of 1:1.5:3. The desired characteristic strength of 20 N/mm2 at 28 days was used in this study. Concrete were prepared for this study in five sets. All set were prepared in control mix in w/c = 0.45. The mix proportions obtained for the various mixes cast are tabulated in Table below.

Mix Designation (M20)	Water (W), ltr	Cement (C), kg	Fine Aggregates (FA), kg	Marble powder, kg	Coarse Aggregates (CA), kg
00 %	0.642	1.47	2.205	00	4.41
05 %	0.642	1.38	2.205	0.073	4.41
10%	0.642	1.31	2.205	0.146	4.41
15%	0.642	1.23	2.205	0.221	4.41
20%	0.642	1.16	2.205	0.293	4.41

Table 1: Proportions of concrete mixtures for compressive strength

Mix Designation (M20)	Water (W), ltr	Cement (C), kg	Fine Aggregates (FA), kg	Marble powder, kg	Coarse Aggregates (CA), kg
00 %	1.022	2.272	3.408	00	6.816
05 %	1.022	2.159	3.408	0.112	6.816
10%	1.022	2.045	3.408	0.226	6.816
15%	1.022	1.932	3.408	0.339	6.816
20%	1.022	1.818	3.408	0.453	6.816

Table 2: Proportions of concrete mixtures for split tensile strength

Mix Designation (M20)	Water (W), ltr	Cement (C), kg	Fine Aggregates (FA), kg	Marble powder, kg	Coarse Aggregates (CA), kg
00 %	0.98	2.20	3.30	00	6.60
05 %	0.98	2.10	3.30	0.109	6.60
10%	0.98	1.99	3.30	0.218	6.60
15%	0.98	1.88	3.30	0.336	6.60
20%	0.98	1.77	3.30	0.444	6.60

Table 3.: Proportions of concrete mixtures for flexural strength test

V. RESULTS AND DISCUSSION

The experimental program included the following:

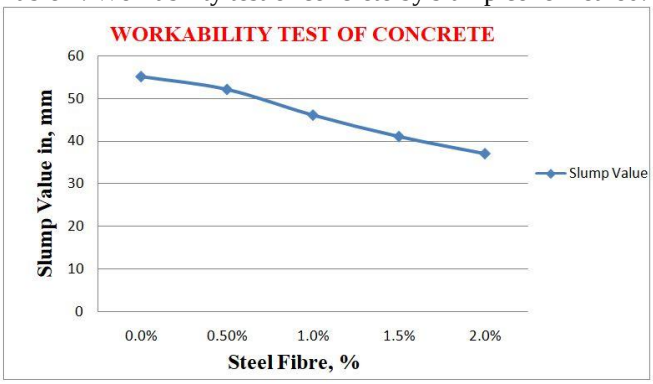
- Testing of properties of materials used for making concrete.
- Design of mixes for modified concrete and steel fibre reinforced concrete by making trials.
- Casting and curing of specimens.
- Tests to determine the compressive strength, split tensile and flexural strength of high strength steel fibre reinforced concrete.

WORKABILITY

Slump cone test was performed on all samples. Concrete mix with 30% marble dust gave the highest slump with 38 mm while steel fibre addition showed a slump measurement of 36 mm to 31 mm. Graph 4.1 shows the decrease in slump measurement when marble dust and steel fibre was added. This result shows that concrete mix with higher fibre content of a constant w/c ratio will give a lower workability as the stability of concrete mix with support of fibres.

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
1	0	62.70	00	55
2	0.5		40	52
3	1.0		80	46
4	1.5		120	41
5	2.0		160	37

Table 4: Workability test of concrete by slump cone method.



Graph 1: Workability test of concrete by slump cone method with different percentage of steel fibre.

COMPRESSIVE STRENGTH

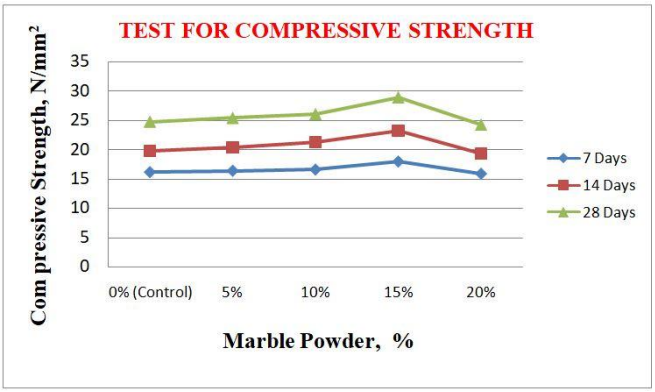
In most structural applications, concrete is employed primarily to resist compressive stresses. When a plain concrete member is subjected to compression, the failure of the member takes place, in its vertical plane along the diagonal. The vertical crack occurs due to lateral tensile strains. A flow in the concrete, which is in the form of micro crack along the vertical axis of the member will take place on the application of axial compression load and propagate further due to the lateral tensile strains. If the concrete contains steel fibres, the crack propagation gets effectively arrested by the fibres oriented at the right angle to the axis of loading. The lateral tensile strain is resisted by the fibres and

hence the compressive strength of the member is increased.

TEST PROCEDURE AND RESULTS

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	C 0	0	16.17	19.75	24.80
2	C 5	5	16.40	20.25	25.45
3	C 10	10	16.60	21.20	26.10
4	C 15	15	17.95	23.15	28.95
5	C 20	20	15.90	19.25	24.30

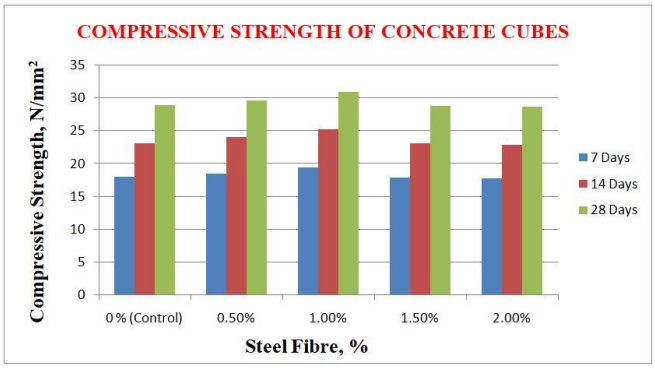
Table 5: Details of Compressive Strength test with various % of marble dust.



Graph 2: Compressive Strength testing of concrete with various % marble dusts.

S.No	Marble powder (15%) + Steel Fiber %	Average Compressive Strength (N/mm^2)		
		7 days	14 days	28 days
1	0 % (Control)	17.95	23.15	28.95
2	0.5%	18.45	24.10	29.65
3	1.0%	19.35	25.25	30.90
4	1.5%	17.90	23.05	28.80
5	2.0%	17.75	22.90	28.65

Table 6: Test results of compressive strength of different mix with different percentage of 15% marble powder & Steel fibre.



Graph 3: Compressive Strength variation of each mix with 15 % of marble powder & different % of Steel fibre.

SPLIT TENSILE STRENGTH

The split tensile strength of all the mixes was determined at the ages 28 days for various replacement levels of marble dust and additional percentages of steel fibres in concrete mix. The results of split tensile strength of concrete are reported in Table 4.4. Table 4.5 shows the gain in split tensile strength for different levels of marble dust replacement with concrete and addition of steel fibre at different time. The split tensile strength results of individual concrete mix are also shown graphically.

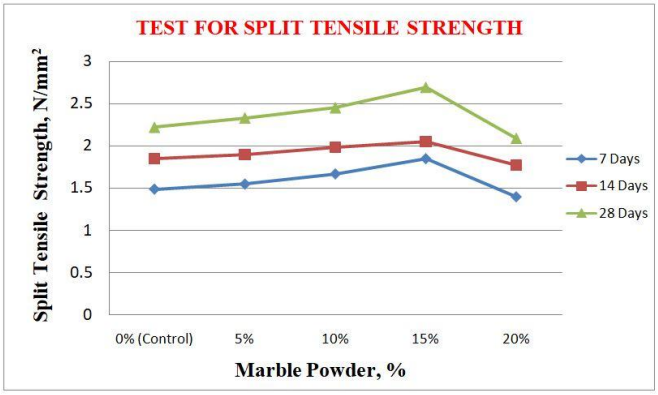
TEST PROCEDURE AND RESULTS

The split tensile strength of all the mixes was determined at the ages 28 days for various replacement levels of MARBLE POWDER and variable percentages of steel fibres in concrete mix. The 150mm × 300 mm size cylinders were casted and tested in the compression testing machine with a uniform rate of 180 kg/min. The results of split tensile strength of concrete show the gain in split tensile strength for different levels of MARBLE POWDER replacement with concrete and addition of steel fibre at different time. The split tensile strength results of individual concrete mix are also shown graphically.

From the results, it is observed that the optimum value of split tensile strength is achieved with addition of 1% of steel fibre in controlled concrete mix. Test results of split tensile strength at the age of 28 days curing are given in Table 4.5. The split tensile strength results of concrete mix are also shown graphically.

S.No	Cylindriacal 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	CY00	0	1.49	1.85	2.22
2	CY 05	5	1.55	1.90	2.33
3	CY 10	10	1.67	1.98	2.45
4	CY 15	15	1.85	2.05	2.69
5	CY 20	20	1.40	1.77	2.09

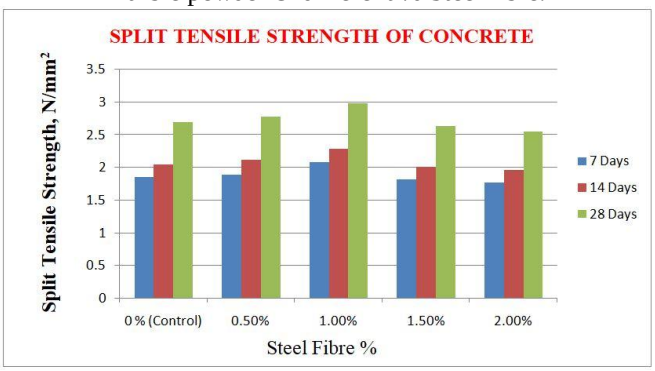
Table 7: Details of Split Tensile Strength test with different % of marble powder.



Graph 4: Split Tensile Strength testing of concrete cylinders with various marble powder %.

S.No	Marble powder (15%) + Steel Fiber %	Average Split Tensile Strength (N/mm^2)		
		7 days	14 days	28 days
1	0 % (Control)	1.85	2.05	2.69
2	0.5%	1.89	2.12	2.78
3	1.0%	2.08	2.29	2.98
4	1.5%	1.82	2.01	2.63
5	2.0%	1.77	1.96	2.55

Table 8: Split tensile strength of different mix with 15% of marble powder & different % Steel fibre.



Graph 5: Test results of split tensile strength of different mix with 15% of marble powder & variable % of Steel fibre.

FLEXURAL STRENGTH

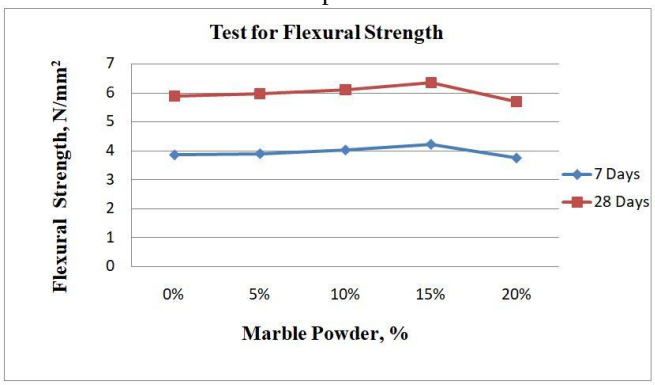
The concrete structure subjected to flexural strength of concrete commonly evaluated by means of bending tests. When concrete is subjected to bending, then tensile and compressive stresses and in many cases direct shear stresses are developed. When fibre reinforced concrete and composite beams are loaded in pure bending, then the tensile strains develop. The load at first crack would increase with respect to steel fibre reinforced concrete due to crack arresting mechanism of the closely spaced fibres. After the concrete matrix cracks, the fibres continue to take higher load which is provided. Thus the ultimate flexural strength is increased.

TEST PROCEDURE AND RESULTS

Test specimens of beam size 100mm×100 mm×500 mm were prepared for testing the flexural strength of steel fibre reinforced concrete and replacement of cement with marble dust in different percentages. The beam moulds containing the test specimens were placed in moist air (at least 90% relative humidity) and a temperature of 270 ±20 C for 24 hours ⁄ hour from the time of addition of water to the dry ingredients. After this the specimens were removed from the moulds and placed in clean fresh water at a temperature of 270 ±20C for the remaining curing period. After 28 days of curing the specimens were tested in flexure on a Universal Testing Machine. Loads were applied at the one third points at a constant rate of 180 kg/minute. The distance between the centers of two rollers was kept 20 cm.

S.No	Beam Sample name	Marble powder, %	7 Days strength, N/mm^2	28 Days strength, N/mm^2
			Average of 3 samples	
1	B0	0	3.85	5.88
2	B 5	5	3.89	5.97
3	B 10	10	4.02	6.10
4	**B 15**	**15**	**4.22**	**6.35**
5	B 20	20	3.74	5.70

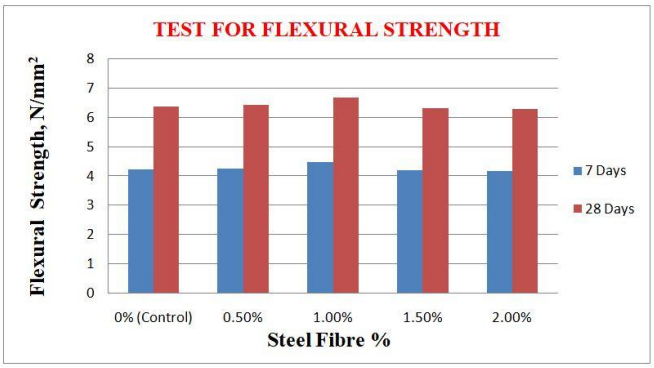
Table 8: Details of Flexural Strength test with different % of marble powder.



Graph 6: Flexural Strength testing of concrete Beam with various marble powder %.

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)	4.22	6.35
2	0.5%	4.26	6.41
3	1.0%	4.48	6.67
4	1.5%	4.20	6.31
5	2.0%	4.16	6.28

Table 9: Flexural strength test results of each mix with 15% of marble powder & Steel fibre.



Graph 7: Flexural Strength variation of each mix with 15 % marble powder & different % Steel fibre.

VI. CONCLUSIONS

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

WORKABILITY

- The compressive strength was found to be maximum with the replacement of 20% of cement with marble powder. Therefore all the studies have been carried out with the replacement of cement with marble powder (20%).
- 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

- These materials should not be used as columns and beams components in buildings due to low compressive, tensile strength and elasticity module values of the samples. Nevertheless, these concretes with low density are designated as flooring, ceiling and wall concrete.
- 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.
- The rate of water absorption of samples is less than 30%. From this result, it is concluded that these materials can be used as concrete and external plaster or inner plaster material that subjected to water.

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] "I.S: 516-1959". Method of test for strength of concrete, Bureau of Indian Standards, New Delhi, 1959.
[2] "IS: 8112-1989". Specifications for 43-Grade Portland cement, Bureau of Indian Standards, and New Delhi, India.
[3] IS: 1199-1959". Indian Standards Methods of Sampling and Analysis of Concrete, Bureau of Indian Standards, New Delhi, India.
[4] "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.
[5] IS: 383- 1970,Indian standard of specification for coarse and fine aggregates from natural sources for concrete(second revision).
[6] 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.
[7] Chen B, Liu J, Properties of lightweight expanded polystyrene concrete reinforced with steel fiber, Cement and Concrete Research, 2004, 34, 1259 — 1263.
[8] 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.
[9] 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 INTERNATIONAL JOURNAL OF CIVIL AND STRUCTURAL ENGINEERING Volume 1, No 4, 2011.
[10] 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).

[11] 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).
[12] 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.
[13] 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.
[14] 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.
[15] 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.
[16] 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.
[17] 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.
[18] Rui D. Neves and Joao C. O. Fernandes de Almeida, 2005. "Compressive behaviour of steel fibre reinforced concrete", structural concrete. 2005-06. No. 1
[19] Saiisik A, Sariisik G, New production process for insulation blocks composed of EPS and lightweight concrete containing pumice aggregate. Mater. Struct., 2002, 45(9), 1345-1357

