

Experimental and Analytical Investigation on Strength Properties of Concrete by Using Partial Replacement of Micro-Silica and Coconut Fibre in Cement

Sanjay S J¹, H Eramma², Harish B A³P.G. Student, Department of Civil Engineering, University B D T College of Engineering, Davanagere, India¹Associate Professor, Department of Civil Engineering, University B D T College of Engineering, Davanagere, India²Assistant Professor, Department of Civil Engineering, G M Institute of Technology, Davanagere, India³

ABSTRACT: The experiment work carried out by micro silica as a supplementary material for cement and evaluate cement for M20 grade of concrete. We are adding 0%, 5%, 10%, 15%, and 20% by weight of cement in concrete. The material chosen for structural up gradation should not pollute the environment. They should be accessible to the ordinary people and low monetary cost. Coconut fibre is abundant, versatile, renewable, cheap and more resistant thermal conductivity. Coconut fibres have the highest toughness amongst natural fibre. They have potential to be used as reinforcement in low cost concrete structures, especially in tropical earth quake region. The aim of investigation is study the possibilities to use coconut fibre in addition to other constituents of concrete and strength properties. The influence of 1%, 2% and 3% fibre content by mass of cement and aspect ratio 125, fibre cut length 2.80cm is investigated. To evaluate the effect of coconut fibres improving the properties of concrete. At 1% addition of coconut fibre, 5% silica fume with water cement ratio 0.53. compressive strength test and split tensile strength gives best result in concrete.

KEYWORDS: Coconut Fibre (CF), Micro-Silica, Aspect Ratio, Compressive Strength, Split Tensile Strength, ANSYS 11.

I. INTRODUCTION

Concrete: Most widely used building material as concrete having a mixture of cement, fine aggregate, coarse aggregate and water which is used for construction of super structures, dams, water tanks, road pavements. The process of selecting suitable ingredients of concrete. Determining the relative amount of concrete with the objective producing a required strength, durability and workability as economical as possible is termed as concrete mix design. The compressive strength of harden concrete generally considered to be an index of its other properties depends upon many factors. The cost of concrete made up of the material plant and labour cost, the variation in the cost of material arise from the fact that cement is several times costlier than aggregates. The aim is to produce a mix as possible from the technical point of view. Concrete mixes may lead to high shrinkage and cracking in the structural concrete. Due to high heat of hydration evolved in mass concrete which may cause cracking. The cost of concrete is related to cost of materials required producing a minimum mean strength called as characteristic strength. This is specified by designer of the structures. This depends on the quality control measures, but there is no doubt that quality control adds to the cost of concrete.

Silica Fume: Silica Fume, also referred to as micro silica or condensed silica fume, it used as a artificial pozzolanic admixture. It is the product resulting from reduction of high purity quartz with coal in an electric arc furnace in the manufacture of silicon. Silica fume raises oxidised vapour. It cools, condensed and collected in cloth bags. It is further

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 7, July 2016

processed to remove impurities and control particle size. Condensed silica fume is essentially silicon dioxide in non-crystalline form. Since it is airborne material like fly ash, it has spherical shape. It is extremely fine with particle size less than 1 micron. Average diameter about 0.1 micron, hundred times about smaller than average cement particles. Silica fume has specific surface area about 20000 m² per kg.

Coconut Fibre: Coconut fibre is extracted from the outer shell of a coconut. The common name is coir, scientific name is *Cocos Nucifera* and plant family *Arecaceae* (plam), respectively. There are two types of coconut fibres, brown fibre extracted from matured coconuts and white fibres extracted from immature coconuts. Brown fibres are thick, strong and have high abrasion resistance, while white fibres are smoother and finer, but also weaker. Coconut fibres are commercially available in three forms, namely bristle (long fibre), mattress (short) and decorticated (mixed). These different types of fibres have different uses depending upon the requirement. In engineering, brown fibres are mostly used.

II. OBJECTIVE OF THE STUDY

The primary goal of this project is to conduct experimental studies for enhancement of properties of concrete with coconut fibre and silica fume.

1. To evaluate the compressive strength of M20 grade concrete, silica fume and coconut fibre in concrete produce by replacing cement in different percentage 0%, 5%, 10%, 15%, 20% and 0%, 1%, 2%, 3% respectively.
2. To evaluate the split tensile strength of M20 grade of concrete, silica fume and coconut fibre concrete produced by replacing cement by different percentage 0%, 5%, 10%, 15%, 20% and 0%, 1%, 2%, 3% respectively.
3. To carry out analysis in ANSYS 11 and comparing it with experiment results.

III. MATERIALS AND METHODOLOGY

Cement: In this present work Ultratech cement of 43 grade ordinary Portland cement was used for casting cubes and cylinder for all concrete mixes. The cement is uniform colour i.e. grey with a light greenish shade and was free from any hard lumps. The various testes conducted on cement are standard consistency, initial and final setting time, specific gravity, fineness and compressive strength. Testing of cement was done as per IS: 8112-1989. The specific and composition limits of Portland cement are listed in the **Table 1**.

Fine Aggregate (FA): The locally available river sand conforming to grading zone III of table 4 of IS 383-1970 has been used as fine aggregate. The tested as been carried out as per IS: 383-1970 is listed in the **Table 2**. **Coarse Aggregate (CA):** Locally available crushed granite coarse aggregate has been used. It is necessary to know the specific gravity and water absorption of aggregate in order to determine the mix proportions of the concrete. Accordingly, tests have been carried out as per the procedure given in IS 2386 (PART 3)-1963 and result presented in the **Table 2**. The present work having maximum size 20mm coarse aggregate used. **Silica**

Fume (SF): Silica fume from SAI DURGHA ENTERPRISES, BANGALORE, Karnataka. **Table 3.** **Coconut Fibre (CF):** Coconut fibre from ROPE INDUSTRY, HOSADURGA, Karnataka. **Table 4.** **Water (H₂O):** Potable tap water was used for the preparation of specimens and for curing specimens. **Table 4.**

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 7, July 2016



Fig 1: Micro silica



Fig 2: Coconut Fibre

Table 1: Physical properties of Cement.

| Particulars | Experimental result | As per standard IS:8112-1989 |
|---------------------|---------------------|------------------------------|
| Specific gravity | 3.08 | 3.15 |
| Setting time (min) | | |
| Initial setting | 52 min | Not less than 30 min |
| Final setting | 240min | Not more than 600 min |
| Comp. strength(MPa) | | |
| 3 days | 20.79MPa | 16MPa (minimum) |
| 7 days | 36.22MPa | 22MPa (minimum) |
| 28 days | 45.93MPa | 43MPa (minimum) |
| Fineness of cement | 5.33% | <10% |

Table 2: Physical properties of FA & CA

| Physical properties of FA | | Physical properties of CA | |
|---------------------------|--------|---------------------------|--------|
| Property | Result | Property | Result |
| Specific gravity | 2.60 | Specific Gravity | 2.63 |
| Fineness modulus | 2.01 | Fineness modulus | 2.67 |
| Grading zone | III | Impact test | 6.9% |
| Water Absorption | 1% | Water Absorption | 0.26% |
| - | - | Angularity Number | 9.84 |
| - | - | Crushing value | 12% |

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 7, July 2016

Table 3: Physical & Chemical properties of SF

| Physical properties of SF | | Chemical properties of SF | |
|---|-------------------------------------|---------------------------|---------------------------|
| Product | Crystalline silica (quartz) | SiO ₂ | >95% |
| Molecular formula | SiO ₂ | Moisture | <1% |
| Physical state | Powder | Loss on ignition | <6% |
| Appearance and odour | White powder, odourless | Specific surfaces | 15-28 |
| Specific gravity (H ₂ O=1.0) | 2.65 g/cm | Bulk density | 450-650 kg/m ³ |
| Boiling water | 2230 ⁰ F | pH value | 6-6.5 |
| Melting | 1710 ⁰ F | Coarse particles | -300 mesh |
| Solubility water | Insoluble | - | - |
| Molecular weight | 60.09 g/mol | - | - |

Table 4: Physical properties of H₂O & CF

| Physical Properties of H ₂ O | | Physical properties of CF. | |
|---|---------------|----------------------------|-----------|
| Parameter | Amount | Diameter | 0.0226 cm |
| PH value | 7.0 | Length | 19.43 cm |
| Taste | Agreeable | Aspect ratio | 125 |
| Appearance | Normal | Cut length | 2.80 cm |

IV.MIX DESIGN AS PER IS:10262:2009

The mix proportions obtained are as shown in the **Table 8.**

Table 5: Mix Proportions

| W/C ratio | Water (kg/m ³) | Cement (kg/m ³) | Fine aggregate (kg/m ³) | Coarse aggregate (kg/m ³) |
|-----------|-----------------------------|-----------------------------|-------------------------------------|---------------------------------------|
| 0.53 | 191 | 360.37 | 667.50 | 1144.75 |

Concrete mix designations are as shown in the **Table 9.**

Table 6: Concrete mix designations

| Mix designation | Description |
|-----------------|-------------------------------|
| M0 | Control concrete of grade M20 |
| M1 | 5% Silica fume + 95% Cement |
| M2 | 10% Silica fume + 90% Cement |
| M3 | 15% Silica fume + 85% Cement |
| M4 | 20% Silica fume + 80% Cement |

To achieve the specific objectives of present work, the experimental programme is presented **Table 10.**

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 7, July 2016

Table 7: Experimental programme

| Concrete mix | Days of curing | Compression StrengthTest | Split Tensile Strength Test |
|---------------|----------------|--------------------------|-----------------------------|
| M0 | 28 | 12 | 12 |
| M1 | 28 | 12 | 12 |
| M2 | 28 | 12 | 12 |
| M3 | 28 | 12 | 12 |
| M4 | 28 | 12 | 12 |
| Total Numbers | | 60 | 60 |

The total number of specimens tested is 120.

V.EXPERIMENTAL RESULTS

Compressive Strength Test Results:For each concrete mix, the compressive strength is determined on three cube of size 150×150×150mm at 28 days of curing. Following table give the compressive strength test results of control concrete and silica fume concrete produced with 5, 10, 15 and 20% of silica fume and 1%, 2%, and 3%, of coconut fibre.The table below gives the overall result of compressive strength of silica fume and coconut fibre concrete produced with different percentages of silica fume and coconut fibre. The variation of compressive strength in the form of graph as shown in fig 3.

Split Tensile Strength Test Result:Test has been conducted after 28 days of curing. Split tensile is conducted on 150mm diameter and 300mm length cylinders as per IS 5816 – 1999.Following table give split tensile strength test results of control concrete and silica fume and coconut fibre concrete produced with 5, 10, 15, 20% of silica fume and 1%, 2%, and 3% of coconut fibre. The table below gives the overall result of split tensile strength of silica fume and coconut fibre concrete produced with different percentages of silica fume and coconut fibre. The variation of split tensile strength in the form of graph as shown in fig 4.

Table 8:Compressive Strength (N/mm²) for 28days

| Mix Designation | 0% fibre | 1% fibre | 2% fibre | 3% fibre |
|-----------------|----------|----------|----------|----------|
| M0 | 27.55 | 28.88 | 28.14 | 21.92 |
| M1 | 29.33 | 33.61 | 30.07 | 22.66 |
| M2 | 31.11 | 29.47 | 25.77 | 22.36 |
| M3 | 28.29 | 29.33 | 22.22 | 21.47 |
| M4 | 26.81 | 26.34 | 20.00 | 21.01 |

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 7, July 2016

Table9: Split Tensile Strength (N/mm²) for 28 days

| Mix Designation | 0% fibre | 1% fibre | 2% fibre | 3% fibre |
|-----------------|----------|----------|----------|----------|
| M0 | 2.68 | 2.59 | 2.68 | 2.40 |
| M1 | 2.91 | 3.11 | 3.01 | 2.82 |
| M2 | 3.25 | 2.68 | 2.58 | 2.26 |
| M3 | 2.82 | 2.63 | 2.49 | 2.21 |
| M4 | 2.77 | 2.40 | 2.44 | 2.00 |

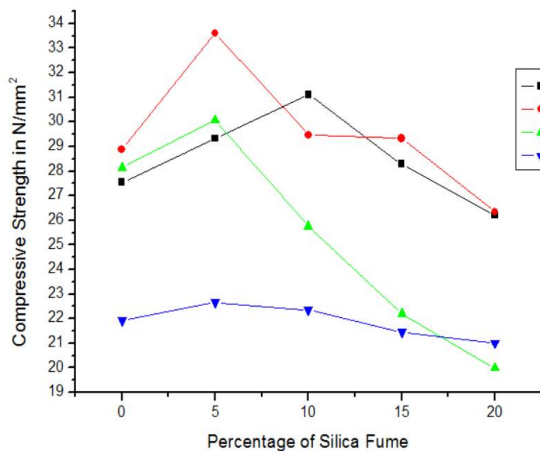


Fig 3. Overall Result of Compressive strength

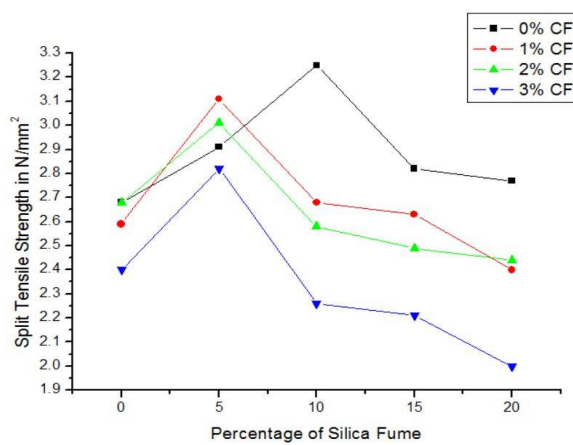


Fig 4. Overall Result of Split Tensile strength

The experimental work carried out by using various percentage of micro silica and coconut fibre can be replaced by weight of cement. The 10% Silica fume in normal concrete increases compressive and split tensile strength and 1% coconut fibre & 5% Silica fume in concrete increases compressive & split tensile strength.

VII. FINITE ELEMENT ANALYSIS

ANSYS is a common reason finite aspect evaluation program developed. Supported and marketed by way of ANSYS. Formerly Swanson Analysis process Inc., founded in 1970 by means of Dr. John A. Swanson. ANSYS Inc. Is a world innovator of simulation program and technologies supplying a powerful suite of engineering simulation instrument which speed up the product progress process at much less computational and financial expenditure. ANSYS simulation solution are used by several Fortune 500 companies to produce a wide range of products, including aircraft and automobile engines, spacecraft, computer chips, buildings offices furniture and medical devices.

Table 10: Comparison of analytical and experimental result for a compressive strength for cubes. (N/mm²)

| Mix designation | 0% CF | | 1% CF | | 2% CF | | 3% CF | |
|-----------------|--------|--------|--------|--------|--------|--------|--------|--------|
| | EXP | ANY | EXP | ANY | EXP | ANY | EXP | ANY |
| M0 | 620.00 | 626.57 | 650.00 | 665.81 | 633.33 | 640.04 | 493.33 | 498.56 |
| M1 | 660.00 | 665.90 | 756.67 | 764.73 | 676.66 | 683.83 | 510.00 | 515.40 |
| M2 | 700.00 | 706.26 | 663.33 | 670.36 | 580.00 | 586.15 | 503.33 | 508.66 |
| M3 | 636.66 | 635.64 | 660.00 | 666.99 | 500.00 | 505.30 | 483.33 | 488.45 |
| M4 | 600.00 | 605.37 | 593.33 | 599.62 | 443.33 | 448.03 | 473.33 | 478.35 |

Table 11: Comparison of analytical and experimental result for a split tensile strength for cylinders. (N/mm²)

| Mix designation | 0% CF | | 1% CF | | 2% CF | | 3% CF | |
|-----------------|--------|--------|--------|--------|--------|--------|--------|--------|
| | EXP | ANY | EXP | ANY | EXP | ANY | EXP | ANY |
| M0 | 190.00 | 192.15 | 183.33 | 185.07 | 190.00 | 192.53 | 170.00 | 171.93 |
| M1 | 206.67 | 208.33 | 220.00 | 222.49 | 213.33 | 215.47 | 200.00 | 202.27 |
| M2 | 226.57 | 228.56 | 190.00 | 192.15 | 183.33 | 185.07 | 160.00 | 161.81 |
| M3 | 200.00 | 202.26 | 186.67 | 188.10 | 176.67 | 177.99 | 156.67 | 158.27 |
| M4 | 196.67 | 198.22 | 170.00 | 171.92 | 173.33 | 174.96 | 140.00 | 141.70 |

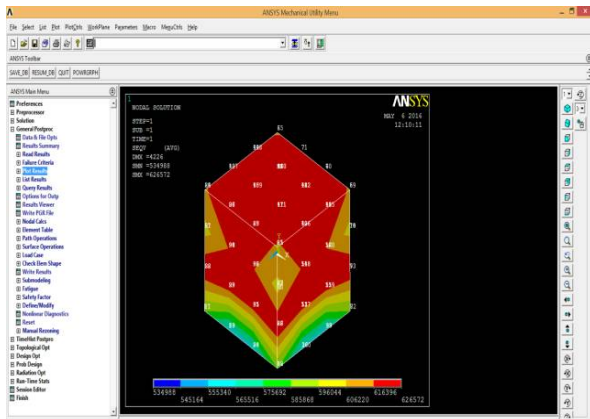


Fig 5: Cube Model in ANSYS

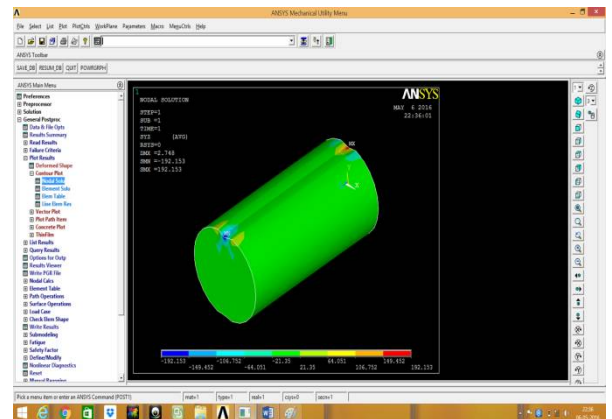


Fig6: Cylinder model in ANSYS

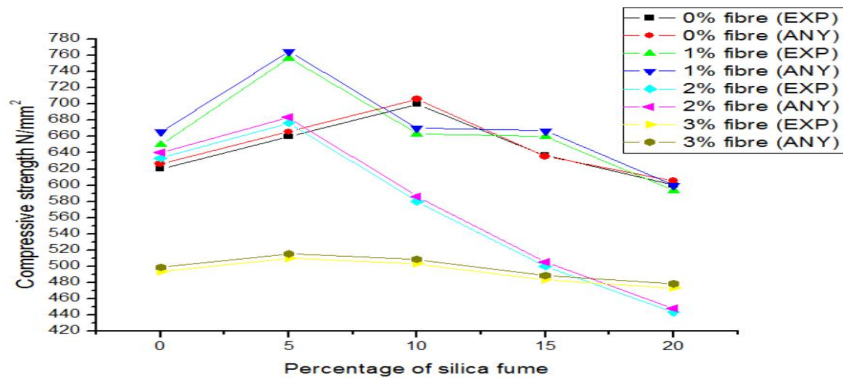


Fig 7: Comparison of result for experimental and analytical results (cubes)

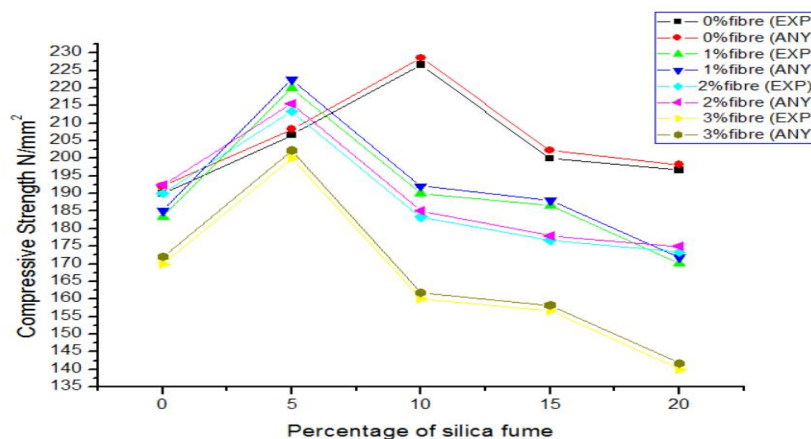


Fig 8: Comparison of result for experimental and analytical results (cylinder)

The Comparison of result for analytical and experimental. The analytical result are calculated by using ANSYS software. The various percentage of silica fume and coconut fibre can be replaced by weight of cement can be replaced. Result can be compared both cube and cylinder

VII.CONCLUSIONS

Based on the limited experimental investigation concerning compressive strength and split tensile strength of concrete with silica fume and coconut fibre as a partial replacement of cement, the following conclusion can be drawn.

1. The compressive strength of concrete is increased by the use of silica fume up to 10% replacement of cement. From 10% there is a decrease in compressive strength.
2. The split tensile strength of concrete is increased by use of silica fume up to 10% replacement of cement. From 10% there is a decrease in split tensile strength.
3. The compressive strength mainly depends on the percentage of silica fume because of its high pozzolanic nature to form more densely packed C-S-H gel.
4. The split tensile strength increases mainly due to improvement in packing, i.e., action of it as a filler material.
5. The optimum percentage of replacement of cement by silica fume is 10% for M20grade of concrete.
6. At 1% addition of coconut fibre, 5% silica fume with water cement ratio 0.53.compressive strength test and split tensile strength gives best result in concrete.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 7, July 2016

7. Due to its relatively higher strength and ductility, it can be a good replacement for asbestos fibres in roofing sheets, which being natural in origin pose zero threat to the environment.
8. Coconut fibre being low density reduces the overall weight of the fibre reinforced concrete thus it can be used as a structural light weight concrete.
9. The coconut fibres are freely available, we can reduce the environmental waste.

ACKNOWLEDGEMENT

“The authors wish to thank the authorities of Visvesvaraya Technological University for giving an opportunity to conduct the experimental work in the concrete and highway materials laboratory of University BDT College of Engineering, Davanagere, Karnataka, India.”

REFERENCES

- 1) Verma Ajay, Chandak Rajeev and Yadav R K (2012), “Effect of Micro Silica on The Strength of Concrete with Ordinary Portland Cement”, Vol.1 (3).
- 2) Debabrata Pradhan, D.Dutta, in their journal entitled (2013), “Influence of Silica Fume on Normal Concrete”, Vol .14, Issue 1.
- 3) Faseyemi Victor Ajileye in their papers entitled (2012) “Investigations on Micro silica(Silica Fume) As Partial Cement Replacement in Concrete”, vol 14, Issue 1, Version 1.0.
- 4) T.Jeevetha, Dr.S Krishnamurthy and G.S.Rampradheep in their journal entitled (2014), “Study on Strength Properties of Self-Compacting Concrete with Micro Silica”, Vol 5, Issue 9.
- 5) Hanumesh B M, B K Varun, Harish B A (2015) “The Mechanical Properties of Concrete Incorporating Silica Fume as Partial Replacement of Cement”, Volume 5, Issue 9.
- 6) Aditya Dhagat, Manav Mittal in their paper entitled (2013), “Effect of Micro silica and Fly ash on the Strength of Concrete”, Vol 6, Issue 4.
- 7) Majid Ali, Anthony Liu, Hou Sou, Nawawi Chouw (2012), “Mechanical and Dynamic Properties of Coconut Fibre Reinforced Concrete”, Construction and Building Materials 30 (2012) 814-825.
- 8) Kshitija Nadgouda (2014), “Coconut Fibre Reinforced Concrete”.
- 9) Shreeshail.B.H, Jaydeep Chougale, Dhanraj Pimple, Amar Kulkarni (2014), “Effect Of Coconut Fibres On The Properties Of Concrete”, Vol 3, Issue: 12.
- 10) Mahapara Abbass (2015), “Coconut fibre as fibre reinforcement”, ISSN: 2348-8352.
- 11) Mahyuddin Ramil, Wai Hoe Kawn, Noor Faisal Abas (2012), “Strength and durability of coconut-fibre-reinforced concrete in aggressive environments”, Construction and Building Materials 38(2012)554-566.
- 12) Umesh Sharma, Ankita Khatri and Abhishek Kanoungo (2014) “Use of Micro-silica as Additive to Concrete – state of Art, volume-5, pp. 9-12.
- 13) A Zuraid, H Zahurin, I Sopiyan (2011). “Effect of fibre length variation on physical and mechanical properties of coir fibre reinforced concrete”, Materials Physical and Mechanics 16(2013)107-117.
- 14) Bhowmick B.B and Debnath C.R (2007), “Properties of coir”, India coconut journal, 15(5).2007, p.12.
- 15) Gambhir M L, Reprint 2010, “Concrete Technology”, TataMcGraw Hill publishing company Ltd., NewDelhi.
- 16) Hassan A. Mohamadienin (2012) “The Effect of marble powder and silica fume as partial replacement for cement on mortar”.
- 17) K.C.Biswal and Suresh Chandra Sadangi (March 2011) “Effect of superplasticizer and silica fume on properties of concrete”.
- 18) M.S Shetty, Reprint 2009, “Concrete Technology”, S.Chand & company Ltd., New Delhi.
- 19) Sai Dhurga Enterprises, Imports & Exporters, Bangalore.
- 20) T.Jeevetha, Dr. S Krishnamurthy and G.S.Rampradheep (April 2014) “Study on Strength Properties of Self-Compacting Concrete with Micro Silica”.
- 21) T.Shanmugapriya, Dr.R.N.Uma (2013) “Experimental Investigation on Silica Fume as partial Replacement of Cement in High Performance Concrete”.
- 22) US Department of Transportation and Highway Administration (2005) “Silica Fume User’s Manual”.

CODE OF PRACTICE

1. IS 10262: 2009 (Specifications for concrete mix design).
2. IS 456: 2000 (Plain and reinforced concrete - code of practice).
3. IS 2386 (Part 3): 1963 (Methods of test for aggregates for concrete).
4. IS 383: 1970 (Specification for coarse and fine aggregate).
5. IS 516: 1959 (Specifications for compressive strength).
6. IS 5816: 1999 (Specifications for split tensile strength).
7. IS 8112: 1989 (Specifications for 43 grade ordinary Portland cement).