March - April 2020
ISSN: 0193-4120 Page No. 1956 - 1963

Experimental Study on Toughness Property of Fiber Reinforced Self Compacting Concrete (FRSCC)

G.Uma Maheswari[1] Suthari Bramarambika[2]
uma.mahi1515@gmail.com,ambikasuthari@gmail.com
[1,2]Dr.KV Subba Reddy College of Engineering for Women, Kurnool,India.

Article Info
Volume 83
Page Number: 1956 - 1963
Publication Issue:
March - April 2020

Article History
***Article Received**: 24 July 2019*
***Revised**: 12 September 2019*
***Accepted**: 15 February 2020*
***Publication**: 18 March 2020*

Abstract
The objective of this work is to investigate the toughness property of the fibre braced self-compacting concrete (FRSCC) through preliminary considers. Fibbers' are used to arrest the cracks in the concrete, and also improve the toughness property of the concrete. Right now, (0.5%, 1.0%, 1.5%, and 2%) percent of steel strands are included by volume of concrete and (0.5% and 1.0%) percent of polypropylene filaments are included .The mix plan of self-compacting concrete has been done by the EFNARC rules. The limitations also achieved according to the European guidelines. By using different types of fibers the toughness property of the FRSCC has been studied. It has been observed that the toughness increased with an increase in % of fibers up to 1.5%. While an increase in % fibre content beyond 1.5% resulted in lower toughness for the steel fibers. It gives the sole the limitation of steel fiber for SCC is up to 1.5% of the volume of concrete. The comparative study also reported for mechanical properties of polypropylene fiber reinforced self-compacting concrete.

***Keywords:** fiber reinforced self compacting concrete (FRSCC), poly-propylene fibers.*

INTRODUCTION:

Concrete plays an extremely important role in the construction of various structures for the improvement of our living environment. A tremendous measure of cement has been utilized as development material. There is no doubt that its use as a major construction material will continue in the future. Concrete for the 21st century will have to be more durable, easier to apply, more predictable and greener. At the same time, it will have to be more cost-competitive. There is extensive evidence to show that concrete materials and concrete structures all over the world are deteriorating at a rapid rate and that it has not been possible to make sure their long-term durable service life performance.

Self-compacting concrete (SCC) is used in the new design and casting of non-conventional architectural details and shapes. There is no need for compacting that can be flown in too tight and inaccessible spaces without requiring vibration. For SCC, it is required to use the super plasticizers to obtain the flow ability and also the viscosity modifier admixture has reduced the segregation. As SCC demand more of finer material, the powder materials like ash, silica fume, limestone powder, are to be added. Recycled Traditional Roof Tile Powder was introduced by Herbudiman and Saptaji, 2013] in SCC. The effect of recycled coarse aggregate on the mechanical properties of SCC is reported to be less compared to normal vibrating concrete (NVC) [Panda and Bal, 2013]. Later the permeability properties of SCC with recycled coarse aggregate did not affect the water permeability [Castro-Gomes and Vila, 2014]. The addition of baggage ash and limestone as fine aggregate in SCC [Makul, 2013] resulted in good workability and hardened properties. By adding the polypropylene fiber in SCC the ductility properties were increased for low-normal- high strength concrete. Later the different types of mineral admixtures (limestone and recycled concrete powder) and fibers (steel, Poly-vinyl-alcohol PVA and Poly-propylene) were added [Corinaldesi, 2011] to find the characterization of SCC by testing the slump, L-box and V-funnel, it shows good results for SCC with steel and recycled concrete powder. Flexural behavior of SCC with a different type of steel (straight and

March - April 2020
ISSN: 0193-4120 Page No. 1956 - 1963

hook end) fibers [Pajak and Ponikiewski, 2013] were done and compared with normal vibrating concrete it shows the maximum crack with lower deflection. The effect of the super plasticizers on the SCC [8], it increases the setting time when increasing the dosage of super plasticizers [Dubey and Kumar, 2012]. The toughness property of the fiber-reinforced self-compacting concrete (FRSCC) through experimental studies have been reported in this paper. The addition of fly ash up to 30% to replace cement was considered. It contain 0.5%, 1.0%, 1.5% and 2.0% of steel fibers and 0.5% 1.0% of polypropylene fiber by volume were added by percentage of binder material.

MATERIALS AND METHODOLOGY:

AGGREGATES

Coarse aggregate: Aggregates predominately retained on the No. 4 (4.75 mm) sieve. For mass concrete, **the utmost** size **is often** as large as 150 mm.

Fine aggregate (sand): Aggregates passing No.4 (4.75 mm) sieve and predominately retained on the No. 200 (75 µm) sieve.

Table 1. Physical properties of aggregates

Aggregate	Specific gravity	Water Absorption
Coarse Aggregate (20 mm & 10 mm)	2.74	2%
Fine aggregate (River Sand)	2.7	3%

CEMENT

The cement used for self -compacting concrete is Portland cement 53 grade.

Table 2: Chemical analysis of the Portland cement

S.No	Oxide Compounds	Weight in %
1	SiO_2	35.4
2	Al_2O_3	17.5
3	Fe_2O_3	5.3
4.	CaO	26.1
5.	MgO	4.6
6.	SO_3	2.8

FLY ASH

CLASS F: The burning of harder, older anthracite, and **soft coal** typically produces Class F ash. This ash is pozzolanic and contains but 20% lime (CaO). Possessing pozzolanic properties, the glassy silica and alumina **of sophistication** Class F ash require a cementing agent, like **hydraulic cement**, quicklime, or **calcium hydroxide**, with the presence of water to respond and deliver cementitious mixes. Alternatively, the addition of a chemical activator-like**e soluble glass** (water glass) to **a category** F ash can **result in** the formation of a geopolymer.

CLASS C: *Debris delivered from the consuming of more youthful lignite or sub delicate coal*, **additionally** to having pozzolanic properties, also has some self-cementing properties.

In the presence of water, Class C **ash** will harden and gain strength over time.

generally contains more than 20% lime (CaO). Self-cementing Class C fly ash does not require an activator which is different from Class F. In Class C fly ashes Alkali and sulfate (SO4) contents are generally higher.

In this examination Class F fly, ash was used. Its chemical composition is shown in Table 3. It is prominent to have a requires amount of cement paste in SCC. A total of 30% of the mass of cement was replaced with fly ash since it has been used to increase the cement paste hence it flows easily.

SUPER PLASTICIZER

In the present work, a super plasticizer (SP) of poly carboxylic either (GELENIUM, BASF Co.) with 1.1 g/cm3 specific gravity (at 20^o C) was used. The properties are given in Table 4. In developing a SSC, the super plasticizer is used to get workability and viscosity properties.

Table 3: Chemical analysis of fly ash

S.No	Compound	ASTM C618 Requirements, %
1	$SiO_{2+}Al_2O_3$ +Fe_2O_3, Min	70
2	SO_3 Max	5
3	Moisture Content	3
4.	LOI	6

Table 4: Properties of the Chemical Admixture

Specif ic Gravi	p H	Solid Conte nt	Recommen ded per 100 Kg of	Compone nt

March - April 2020
ISSN: 0193-4120 Page No. 1956 - 1963

ty			Cement Content	
1.115	5-8	40	0.8-2.0 Lit	Poly Carboxylic Ether

TYPES OF FIBERS

In this work, two types of fibers were used. They are steel and poly-propylene fibers shown in fig 1. The type of steel fiber having aspect ratio of 50 and geometry of crimped shape was used. The detail properties of fibers are given in Table 5.

Table.4.5: Properties of the fibers

Fiber	Length (mm)	Diameter (mm)	Aspect Ratio	Tensile Strength (Mpa)	Elasticity Modulus (Gpa)	Specific Gravity (g/cm^3)
Steel	50	1.0	50	1.25 ×10^3	200	7.48
Poly-Propylene	25	0.1	250	0.55 ×10^3	8	0.9

DETAIL MIX PROPORTION

The mix design done according to the Indian standard IS 10262-2009 for M25 grade of concrete. Fresh concrete contain 30% of fly-ash as cement replacement by mass basis. Fresh fiber reinforcement concrete contain 0.5%, 1.0%, 1.5% and 2.0% of steel fibres are added on basis of volume of concrete. The polypropylene fiber with 0.5% and 1.0% were added by mass of binder material. The details are shown in Table1

Table : Details of Mix Proportion

Material (Kg/m^3)	0.5% of Poly-Propylene Fiber	1.0% of Poly-Propylene Fiber	0.5% of Steel Fiber	1.0% of Steel Fiber	1.5% of Steel Fiber	2.0% of Steel Fiber
Cement	358.05	358.05	358.05	358.05	358.05	358.05
Fly-ash	153.45	153.45	153.45	153.45	153.45	153.45
Fine aggregate	757.11	757.11	757.11	757.11	757.11	757.11
Course aggregate	651.11	651.11	651.11	651.11	651.11	651.11
Water Content	186	186	186	186	186	186
Super plasticizer	3.07	3.07	3.07	3.07	3.07	3.07
Fiber	2.55	5.11	12	24	36	48

TESTING, CASTING AND CURING

TESTS ON FRESH PROPERTIES OF SCC

The characteristics of self compacting concrete (SCC) is obtained by the following tests according to the EFNARC guidelines. The flow ability of concrete can be achieved by normal slump test

- Slump test (Flow ability)
- T_{500} Time (Viscosity)
- V- Funnel (Viscosity/ Flow ability)
- L-box (Passing ability)

SLUMP TEST AND T_{500} TIME:

Numerous test methods are available for measuring the rheological behaviour and the workability of concrete with or without fiber

March - April 2020
ISSN: 0193-4120 Page No. 1956 - 1963

reinforcement .Workability methods used in this study standardized by the Self-Compacting Concrete Committee of EFNARCS [1] were followed. Slump flow grades
SF1: Flow 550 - 650 mm
SF2: Flow 650 - 750 mm
SF3: Flow 750 - 850 mm

.

Fig : Slump test (Flow ability)

The Slump obtained is **640 mm** lies according to EFNARC guidelines (550-650 mm).

Time to flow the 500 mm Dia., is observed to be **4.6 Sec**.

V- FUNNEL TEST

The V-funnel test is employed to work out the fluidity or viscosity of concrete. The V-funnel filled with concrete and the time it takes for the concrete to flow through the apparatus is measured. Good flow able and stable concrete would take a short time to flow out.

The equipment consists of a v shaped funnel as, show in Fig 4. An alternative type of V-funnel, the O funnel, with circular has been used. The test was developed in Japan and used by Ozawa et al. The equipment consists of V-shaped funnel section is additionally utilized in Japan. The described V-funnel test is employed to work out the filling ability (flow ability) of the concrete with a maximum aggregate size of 20mm. The funnel is crammed with about 12 litre of concrete and therefore the taken for it to flow through the apparatus measured. After this the funnel are often refilled concrete and left for five minutes to settle. The flow time will increases significantly If the concrete shows segregation.

The time taken to concrete to flow is 18 Sec

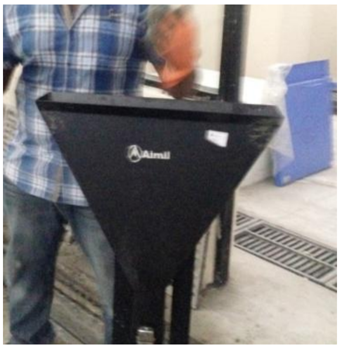

Fig.7.3: V-funnel Test (Passing Ability)

L-BOX TEST

The test assesses the flow of the concrete and also the extent to which it's subjected to blocking by reinforcement. The apparatus is shown in the figure. The apparatus contains rectangular section box up the form of an 'L', with a vertical and mechanical drawing , separated by a movable gate, vertical length of reinforcement bar are fitted. The mechanical drawing is crammed with concrete, and then the gate lifted to let the concrete flow mechanical drawing. When the flow has stopped, the peak of the concrete at the top of the mechanical drawing is expressed as a proportion of that remaining within the mechanical drawing. When at rest it indicates the slope of the concrete. This is a symbol passing ability, or the degree to which the passage of concrete through the bars is restricted. The mechanical drawing of the box is often marked at 200mm and 400mm from the gate and therefore the times taken to succeed in these points measured. These are referred to as the T20 and T40 times and are a sign for the filling ability. In accordance with normal reinforcement considerations, the section of bar for various diameters and are spaced at different intervals 3x the utmost aggregate size might be appropriate. To impose a more or less severe test of the passing ability of the concrete the bar can principally be set at any spacing.

Set the apparatus level on firm ground, make sure that the sliding gate can open freely then close it. Moisten the within surface of the apparatus, remove any surplus water; fill the mechanical drawing of the apparatus with the concrete sample. Leave it stand for 1 minute. Lift the sliding gate and permit the concrete to effuse into the mechanical drawing. Simultaneously, start the stopwatch and record the

Published by: The Mattingley Publishing Co., Inc.

time for the concrete to succeed in200 and 400 marks. The distances 'H1' and 'H2' are measured When the concrete stops flowing,. Calculate H2/H1, the blocking ratio. The whole has tom performed within 5 minutes.

Passing Ability H2/H1 = 95/120 = 0.79

Fig: L-box test (Passing Ability)

TESTS ON HARDEN CONCRETE

All Cubes and Cylinder tests are carried out in the Compression testing machine with 4000KN capacity. Beam tests are carries out in UTM of 1000 KN with 3-point loading equipment.

TOUGHNESS PROPERTY

There are methods were used for determining the flexural toughness namely: ASTM C1018 and JSCE SF-4. In this study the JSCE SF-4 was used.

ASTM METHOD

In ASTM Cl0l8, with the 4 specified deflections toughness (or energy absorption defined because area under the load deflection curve) is calculated . The toughness is calculated at the pre deflection which is taken into account elastic or pre-peak toughness (first-crack toughness), while the opposite deflection are considered the post-peak toughness.

JSCE SF-4

JSCE SF-4 provides just a single value of toughness which is different from the ASTM Cl0l8. For a given load-deflection curve, toughness is that the area under the load deflection curve measured up to a specified deflection L/150

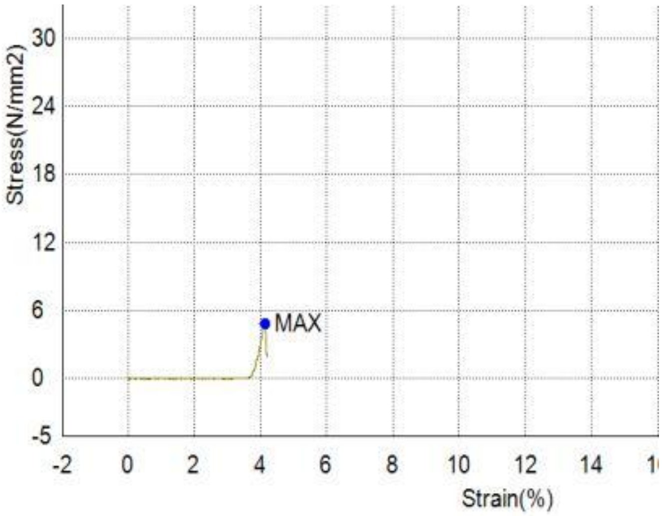

Fig.7.6: Stress- Strain Graph for FRSCC

CASTING AND CURING

Cubes of 150x150x150mm, Cylinders of 150 mm dia & 300 mm height and Beams of size 100 x100 x 500 mm are casted. The specimen details are shown in below Table.

Table.7.1: Specimen Details of Casting and Curing

Grade of concrete with 30 % Fly Ash	Percentage Addition of Fibers	No. of cubes for 28 days	No. of cylinders for 28 days	No. of beams for 28 days
M25	0.5 % PP Fibers	3	3	3
	1.0% PP fibers	3	3	3
	0.5% Steel Fibers	3	3	3
	1.0% Steel Fibers	3	3	3
	1.5 % Steel Fibers	3	3	3
	2.0% Steel Fibers	3	3	3

After remolding, they were placed during a saturated limewater bath until the time of testing. Curing was done in accordance with BIS standard. It is well recognized that adequate

March - April 2020
ISSN: 0193-4120 Page No. 1956 - 1963

curing of concrete is very important not only to achieve the desired strength but also to make durable concrete.

Table : Characteristic Properties of SCC

Test	Result	Limitation Acc to EFNARC
Slump (Flow ability)	640 mm	Minimum 550 mm
T_{500}	4.6 Sec	
L-Box (Passing ability)	H2/H1 = 0.79	≥ 0.75
V-Funnel	18 Sec	Max 30 Sec

1. RESULTS AND DISCUSSION

COMPRESSIVE STRENGTH

The compressive strength of 150x150x150 mm cubes of M25 grade concrete with 30% of cement replaced with fly ash and addition of (0.5%,1.0%, 1.5%, and 2.0%) volume of steel fiber and (0.5% and 1.0%) mass of poly-propylene fiber for 28 days curing are shown in Table 10. Fig 8 shows that the strength of concrete is increased when the percentage of volume of fibers is increased. However there is small decrement of strength for 2.0% of volume of fibers. Expansion of steel filaments helps in changing over the properties of fragile cement to a pliable material. For poly-propylene fibers the compressive strength of concrete is increased gradually.

Table 8: Compressive Strength of FRSCC For 28 Days

S.No	Specimen	Compressive Strength for 28 days (N/mm^2)
1	0.5% of PP	36.95
2	1.0% of PP	42.50
3	0.5% of Steel	36.48
4	1.0% of Steel	49.13
5	1.5% of Steel	49.98
6	2.0% of Steel	49.09

PP- poly- propylene fibre; Steel-steel fiber

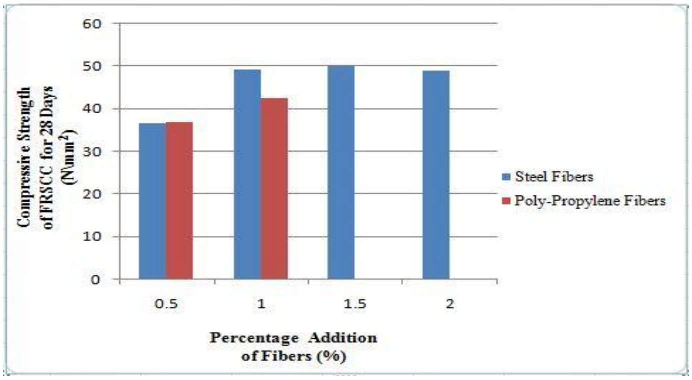

Fig : Compressive Strength of FRSCC for 28 Days

SPLIT TENSILE STRENGTH

The Split tensile strength of 150x300 mm cylinder of M25 grade concrete with 30% of cement replaced with fly ash and addition of (0.5%,1.0%, 1.5%, and 2.0%) volume of steel fiber and (0.5% and 1.0%) mass of poly-propylene fibre for 28 days curing are shown in Table 11. Fig 9 shows that when addition of steel fibbers the split tensile strength of concrete is increased when the percentage of volume of fibbers is increased. Expansion of poly-propylene filaments helps in changing over the properties of fragile cement to a malleable material. When adding the poly propylene fibbers the split tensile strength of concrete is decreased gradually.

Table : Split Tensile Strength of FRSCC for 28 Days

S.No	Specimen	Split Tensile Strength for 28 days (N/mm^2)
1	0.5% of PP	3.21
2	1.0% of PP	3.15
3	0.5% of Steel	2.82
4	1.0% of Steel	3.85
5	1.5% of Steel	4.47
6	2.0% of Steel	4.70

March - April 2020
ISSN: 0193-4120 Page No. 1956 - 1963

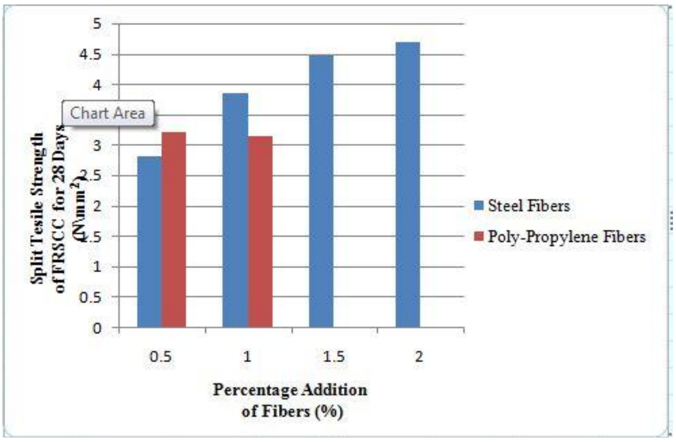

Fig : Split Tensile strength of FRSCC for 28 Days

FLEXURAL STRENGTH

The results of flexural strength are shown in Table 12. It has observed that from Fig. 10 that the strength of concrete is increased when the percentage of volume of fibers is increased. However there is small decrement of strength for 2.0% of volume of fibers. Development of steel strands helps in changing over the properties of delicate concrete to a flexible material. For poly propylene fibers the compressive strength of concrete is increased gradually.

Table : Flexural Strength of FRSCC for 28 Days

S.No	Specimen	Flexural Strength for 28 days (N/mm^2)
1	0.5% of PP	7.24
2	1.0% of PP	9.38
3	0.5% of Steel	7.49
4	1.0% of Steel	9.30
5	1.5% of Steel	12.46
6	2.0% of Steel	11.97

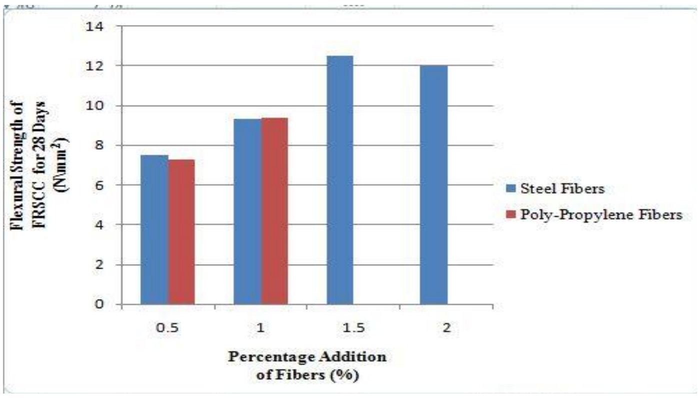

Fig : Flexural Strength of FRSCC for 28 Days

TOUGHNESS

The energy absorption capacity of fiber reinforced self compacting concrete results are shows in Table 12. The sturdiness of the steel fiber SCC shows great outcomes.. To find the toughness the area stress-strain curve up to the deflection of L/150. Toughness is gradually increased when the fibers are added. The steel fibers has more ductile property so it absorbs more energy compared to poly-propylene fibers.

Table Toughness of FRSCC for 28 Days

S.No	Specimen	Flexural Strength for 28 days (N-mm)
1	0.5% of PP	7.24
2	1.0% of PP	9.38
3	0.5% of Steel	7.49
4	1.0% of Steel	9.30
5	1.5% of Steel	12.46
6	2.0% of Steel	11.97

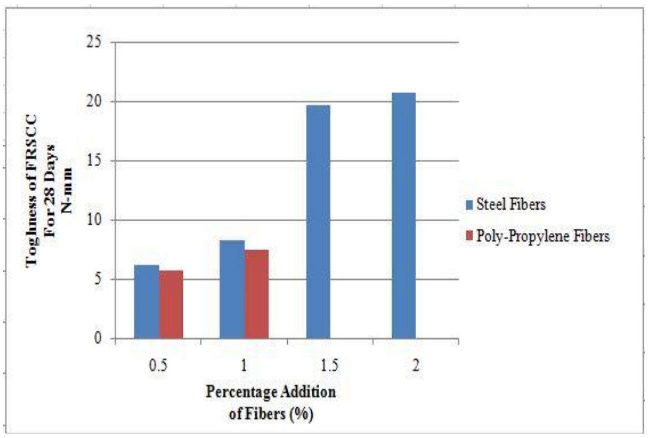

Fig.Toughness Property of FRSCC for 28 Days

CONCLUSION:

•It is observed that self compacting concrete with addition of fibers at 1.5% resulted in good engineering properties such as compressive (49.98 MPA), at 2% of fibers split tensile (4.70 MPA) and at 1.5% fibers flexural strength (12.46 MPA).

•The Features of FRSCC satisfied the European guideline for SCC.

•Addition of steel fibers to SCC, although compressive strength was not improved, split tensile strength got enhanced.

March - April 2020
ISSN: 0193-4120 Page No. 1956 - 1963

•By adding the poly-propylene fibers to fresh concrete the compressive strength is increased gradually, where as the split tensile strength decreases gradually.
•The flexural strength of concrete for poly-propylene fiber increased gradually for steel fibers marginal decrement by adding 2% volume.

REFERENCES:

[1] EFNARC Guidelines for self compacting concrete 2004
[2] Bernardinus Herbudiman and Adhi Mulyawan Saptaji (2013). "SCC with Recycled Traditional Roof Tile Powder." Procedia Engineering 54 (2013) 805 – 816.
[3] KC Panda & P K Bal (2013), "Features of SCC using recycled coarse aggregate." (2013) 159 – 164.
[4] L.A. Pereira-de-Oliveira, M.C.S. Nepomuceno, J.P. Castro-Gomes, M.F.C. Vila (2014) "Permeability properties of self Compacting concrete with recycled aggregates coarse" Construction and Building Materials 51 (2014) 113–120.
[5] Gritsada Sua-iam, Natt Makul (2013). "Utilization of greater amounts of bagasse ash waste to produce self-compacting concrete by adding limestone powder waste" Journal of Cleaner Production 57 (2013) 308-319.
[6] Valeria Corinaldesi, Giacomo Moriconi (2011), "Characterization of SCC prepared with different fibers and mineral additions", Cement & Concrete Composites 33 (2011) 596–601.