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Statistical and Detailed Analysis on Fiber Reinforced Self-Compacting Concrete Containing Admixtures- A State of Art of Review

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Statistical and Detailed Analysis on Fiber Reinforced Self-Compacting Concrete Containing Admixtures- A State of Art of Review

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Abstract. Self-Compacting Concrete is one of the special concretes that have ability to flow and consolidate on its own weight, completely fill the formwork even in the presence of dense reinforcement; whilst maintaining its homogeneity throughout the formwork without any requirement for vibration. Researchers all over the world are developing high performance concrete by adding various Fibers, admixtures in different proportions. Various different kinds Fibers like glass, steel, carbon, Poly propylene and aramid Fibers provide improvement in concrete properties like tensile strength, fatigue characteristic, durability, shrinkage, impact, erosion resistance and serviceability of concrete[6]. It includes fundamental study on fiber reinforced self-compacting concrete with admixtures; its rheological properties, mechanical properties and overview study on design methodology statistical approaches regarding optimizing the concrete performances. The study has been classified into seven basic chapters: introduction, phenomenal study on material properties review on self-compacting concrete, overview on fiber reinforced self-compacting concrete containing admixtures, review on design and analysis of experiment; a statistical approach, summary of existing works on FRSCC and statistical modeling, literature review and, conclusion. It is so eminent to know the resent studies that had been done on polymer based binder materials (fly ash, metakaolin, GGBS, etc.), fiber reinforced concrete and SCC; to do an effective research on fiber reinforced self-compacting concrete containing admixtures. The key aim of the study is to sort-out the research gap and to gain a complete knowledge on polymer based Self compacting fiber reinforced concrete.

1. Introduction

Concrete has been considered as a widely used material next to water. This shows the evident importance of concrete in current day-to-day scenario. The basic ingredients of concrete are cement, coarse aggregate, fine aggregate and water. Admixtures are added to improve its physical and mechanical properties. There are several researches going on, in improving the efficiency of concrete; making concrete more durable, eco-friendly, high strength, cost effective. Self-compacting concrete has become the new trending technique over normally vibrated concrete (NVC). Unlike NVC, SCC does not have standard code for mix design. The presentation of SCC speaks to a noteworthy innovative propel, which prompts a superior nature of cement created and a quicker and more efficient concrete development process[1]. The original SCC utilized as a part of the UK as well as Europe, for example, it is created in a vast European exploration venture, that examined the practicability of utilizing Self-compacting concrete in both structural designing and building structures, which contained a high measurement of binder, and



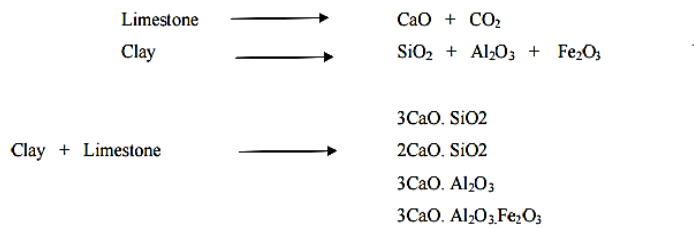
additionally, high measurement of SP, in order to guarantee satisfactory filling capacity and passing capacities and isolation matrices resistance [1].

Concrete is very good in compression and weak tensile properties. Using fibers in concrete is not new, it has in practice from the ancient period (i.e., around 1900's). The concept of composite material came to an act from the year of 1950's. The detailed research is going on in enhancing the properties of tensile properties of concrete, by adding different kinds of fibers and different ratio. Addition of fibers helps in arresting the initial internal micro cracks which is considered as a major reason for failure of concrete, improves the shrinkage and improves the impact resistance [2]. Addition of fibers in self-compacting concrete makes the concrete most effective and efficient concrete, but comparing to normally vibrated concrete (NVC) of almost similar properties. The cost of SCC is more because of the requirement of higher binder content (cementitious material) and chemical admixture including high range water reducing agents (HRWRs) and viscosity Enhancing Admixtures (VEAs). Typically, the content in cementitious materials can vary between 450 and 525 kg/m³ for SCC aimed to fill the densely reinforced areas and advanced for repair applications. Such applications require low volume of aggregate to enhance flow among densely spacing without any blockage, and to ensure the filling of the formwork without any vibration. The introducing high volume of fine powder materials is necessary to improve cohesiveness and to increase the volume of paste for a successful casting of SCC [3]. The combined use of fly ash and silica fume reduces the water absorption and sorptivity, which is much more significant rather than using fly ash alone. It is also noted that increasing the proportions of silica fume and fly ash leads to reduction in water absorption. The addition of these mineral admixtures increases the 28-day compressive strength. However, there is no significant relation between the compressive strength and the sorptivity of SCC [8]. The mixture proportioning of SCC to at the same time meet the different execution necessities at least cost includes the improvement of a few mixture constituents that impact execution. This procedure is entirely complex and can be streamlined by comprehension the relative essentialness of different mixture parameters on key properties of SCC. The epic material content to obtain optimized mix is • SP • (VMA) Viscosity Modifying Agent • Fly ash, silica fume or micro-silica particles • Reduced w/b ratio (binder (b) = cement + fly ash + silica fume) • Limited size of coarse aggregate and volume [148]. This incorporates deformability, passing capacity, filling limit, and segregation resistance. The proportioning of SCC is tedious as a result of the different conflicting necessities expected to guarantee phenomenal stream flow and excellent mechanical properties [4]. The aim of the study is to review completely on self-compacting concrete (SCC), the rheological properties of SCC, effect of fiber-reinforced with SCC (FR-SCC) and impact of addition of mineral admixture in mechanical and durability properties of Fiber Reinforced Self-compacting Concrete containing admixtures like fly ash, silica fume, metakaolin, etc., To study the attainability of utilizing a statistical experimental outline way to determine the relative importance of essential mixture parameters and their coupled impacts on properties of fiber reinforced self-compacting concrete (FRSCC) containing admixtures. This study can be utilized to assess the vital impact of altering matrix variables on solid properties required to guarantee effective improvement of FR-SCC. These models can be an effective assistance to distinguish potential mixtures with a given arrangement of execution criteria that can be attempted in the research center, thus minimizing the test convention expected to streamline and optimize FR-SCC.

2. Phenomenal study on material properties

2.1 Cement:

As cement is the significant part of concrete also, normally has generally low unit cost, the choice of its appropriate sort and utilize has fundamental significance in getting the parity of its coveted properties in most practical route for any specific concrete blend [93]. The generation and structure of Portland cements, its hydration procedures, and its concoction and physical properties have been as often as possible contemplated and scrutinized, with various reports and papers composed on all parts of these properties. The reaction of cement in kiln is shown below,

**Table 1.**Main Types of Cement Produced Around the World

Type	Designation	BS EN notation	Constituents	Applications
Normal Portland cement	Pure	CEM I	Clinker and calcium sulphate	All types of construction except those exposed to sulphate exposure.
Sulphate-resisting Portland cement	Pure	BS EN 197-4	Low C3A clinker and calcium sulphate	Concrete exposed to sulphate attack.
White Portland cement	Pure	CEM I	Special low iron content clinker and calcium sulphate	Architectural finishes.
Portland pulverised fuel ash cement	Composite	CEM II	Clinker, pulverised fuel ash and calcium sulphate	All types of construction, where concrete is required to have improved sulphate resistance and protection against alkali-silica reaction, mass concrete.
Portland slag cement	Composite	CEM III	Clinker, granulated blast-furnace slag and calcium sulphate	All types of construction, where concrete is required to have improved sulphate resistance and protection against alkali-silica reaction, mass concrete.
Portland limestone cement	Composite	CEM II	Clinker, limestone and calcium sulphate	All types of construction.
Pozzolanic cement	Composite	CEM II	Clinker, natural pozzolan and calcium sulphate	All types of construction, particularly where concrete is to improve the durability.

Masonry cement	Composite	BS EN 413-10	Clinker, limestone and air-entraining agent	Brickwork, blockwork and rendering.
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2.2. Mineral Admixture

Supplementary mineral admixtures like silica fume, slag and fly ash when utilized in concrete production, found to be beneficial in improving several properties including strength (as a result of pozzolanic reaction) and permeability (as a result of reduction in porosity and refinement of the microstructure) thereby reducing ingress of water and other harmful salt solutions and in many cases reducing the overall production cost [93].

Table 2. Nature of Composite Cement Constituents [94]

Oxides (%)	Microsilica	Metakaolin
SiO ₂	92.0	52.1
Al ₂ O ₃	0.70	41.0
Fe ₂ O ₃	1.23	4.3
CaO	0.30	0.09
MgO	0.21	1.4
SO ₃	0.33	-
Na ₂ O	1.23	0.01
K ₂ O	0.82	0.62
Ignition loss	3.18	0.48
Specific gravity	2.20	2.40
Surface area (m ² /kg)	15000-20000	12000-15000

The utilization of supplementary materials has discovered across the board applications in the development business likewise as a result of its inclination to go about as a panacea for sturdiness related issues. Plain concrete blends if utilized as a part of mass concrete development like dams would bring about high warmth of hydration subsequently prompting issues like warm splitting. The utilization of materials like fly ash or slag offers the likelihood of decreasing the temperature rise just about in direct extent to measure of Portland cement supplanted (Mehta and Monteiro, 1997). Solidness to chemical assaults is enhanced with the utilization of most fly ashes and slag's principally because of the pore refinement of concrete made with such materials. Tests have demonstrated that cement glues containing 10-30% low calcium fly ash cause critical pore refinement in the 28 to 90 day curing period

2.3. Superplasticizer

The main function of superplasticizer is providing good dispersing effects on cement pastes or concrete, and enhancing the workability. Viscosity is a good parameter indicating the extent of dispersion of a cementitious system. For a well-dispersed cement paste, the cement particles are less aggregated or associated, and it is less viscous [92]. Copolymer was prepared from methacrylic acid and 2-acrylamido-2-methylpropane sulfonic corrosive in an appropriate proportion through free radical polymerization. PCA was observed to be viable in enhancing the workability of the subsequent cementitious materials 2-acrylamide-2-methylpropane sulfonic acid in a proper ratio through free radical polymerization. PCA was found to be effective in improving the workability of the resulting cementitious materials [93-100].

2.4. Fibers

The idea of utilizing fibers in a matrix was first registered with the old Egyptians who utilized hair from creatures and straw as support for mud blocks and dividers in construction [89]. Fiber reinforced concrete was effectively utilized as a part of assortment of building applications, as a result of its agreeable and extraordinary execution in the business and development field. Be that as it may, the majority of the specialists what's more, analysts have felt that how and why the Fibers perform so effectively. Along these lines, to perceive the use of Fibers in concrete, during these recent four decades, a large portion of research and examination was done on behavior of FIBER reinforced concrete (FRC) and the Fibers itself. Fibres are of two types •natural Fibers and •man-made Fibers (synthetic). Natural fibres are extracted from mineral, animal, and plant sources. Fibres from plant sources are coconut, flax, hemp, cotton, jute, kenaf, and sisal. Fibers from animal sources include silk, wool, and mohair. Manmade sources include asbestos, different dimensions of polypropylene and steel fibers [25, 26, & 27]. There has been a quick development in research and advancement in the normal fiber composite (NFC). Intrigue is justified because of the upsides of these materials contrasted with others, for example, man-made fiber composites, including low natural effect and minimal effort and enhances their potential over an extensive variety of utilizations [24]. Vasu deva et al. stated that use of metallic fibers and industrial waste polypropylene fibers, polyethylene terephthalate (PET), high density polyethylene, HDPE are used as reinforcement in conventional concrete [46]. Recent innovations in now incorporate fortification as polymeric filaments, steel or glass strands. FIBER-reinforcement is not utilized for structural strengthening; rather it lessens the prerequisite of measure of rebar's or work and adds to the change of strength by delaying the crack propagation

Table 3. Basic Properties of Fibers [27-45, 47]

fiber	Density (g/cm³)	Length (mm)	Failure strain (%)	Tensile strength (MPa)	Stiffness/Young's modulus (GPa)	Specific tensile strength (MPa/g cm⁻³)	Type of fiber
Ramie	1.5	900–1200	2.0–3.8	400–938	44–128	270–620	Natural
Flax	1.5	5–900	1.2–3.2	345–1830	27–80	230–1220	Natural
Alfa	1.4	350	1.5–2.4	188–308	18–25	134–220	Natural
Coir	1.2	20–150	15–30	131–220	4–6	110–180	Natural
Cotton	1.5–1.6	10–60	3.0–10	287–800	5.5–13	190–530	Natural
E-glass	2.5	Continuous	2.5	2000–3000	70	800–1400	Natural
Feather	0.9	10–30	6.9	100–203	3–10	112–226	Natural
Harakeke	1.3	4–5	4.2–5.8	440–990	14–33	338–761	Natural
Hemp	1.5	5–55	1.6	550–1110	58–70	370–740	Natural
Jute	1.3–1.5	1.5–120	1.5–1.8	393–800	10–55	300–610	Natural
Silk-	1.3	Continuous	15–60	100–1500	5–25	100–1500	Natural
Sisal	1.3–1.5	900	2.0–2.5	507–855	9.4–28	362–610	Natural
Wool	1.3	38–152	13.2–35	50–315	2.3–5	38–242	Natural
PP	1.35	350-650		250-308	1.5-2	280-350	Man made

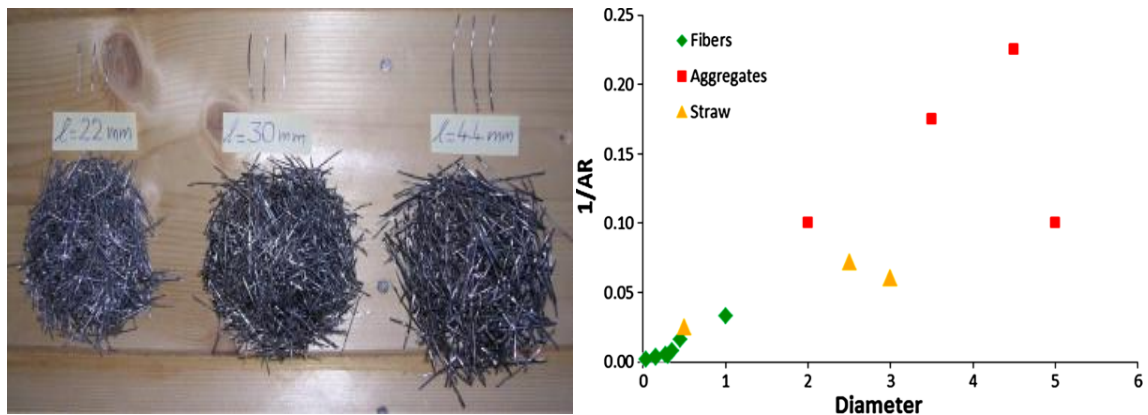


Figure 1. Different types of steel fibers and fibers l/d ratio versus diameter [48 & 23, 45-88]

Inference: the inverse of the aspect ratio (AR) ($1/AR$), which is the proportion of the l/d, versus diameter. It is perceptible that Fibers show the very small $1/AR$ and width and the aggregates have the most astounding $1/AR$ (higher than 0.10). Straw molecule ARs are between the other two, however their measurement can be comparative to those of Fibers or aggregates [23]. Gigantic assorted qualities of plant total and FIBER shapes can in this manner be added to an earth grid, with particular destinations. For occasion, to lessen shrinkage splitting (particularly in mortars), the utilization of plant particles in FIBER structure is ideal. For this situation, the FIBER length will assume an essential part in the non-proliferation of breaks. Nonetheless, when the point is to diminish the heaviness of the composite material, thus expand warm or acoustic protection for illustration, the state of the plant total has a lower sway. The diameter of aggregates is bigger than the one of Fibers [24]. Abbas AL-Ameeri et al [146] observed that, the fresh concrete properties of steel fiber reinforced SCC, results in reduction in workability of concrete, with increase in volume fraction of steel fibers.

Table 4. Properties of Steel Fibers

Type	Length (lf) (mm)	Equivalent diameter (df) (mm)	Aspect ratio (lf/df)	Tensile strength (MPa)	Young's modulus (GPa)
F – DUE 22/50	22	0.44	50	360–410	210
F – DUE 30/50	30	0.60	50	360–410	210
F – DUE 44/50	44	0.88	50	360–410	210

3. Overview on fiber reinforced self-compacting concrete containing admixtures

In the mid-80s, the improvement of self-compacting concrete (SCC) empowered the execution of solid structures with no requirement for vibration since its rheological properties and self-compacting abilities [9]. SCC is considered as a most advanced construction material having high level of workability and good cohesiveness [7]. According to European guidelines for SCC [10], ThiagoMeloGrabois et al.[11] done an experiment on fiber reinforced self-compacting light weight concrete produced SCLC containing either coarse aggregate or coarse and fine lightweight aggregates. Steel Fibers were utilized as reinforcement in FIBER volume part of 0.5%. “V” funnel and slump flow tests were performed to describe the self-compacting conduct of the matrix. As indicated by EFNARC rules concrete can be grouped in three slump flow (SF) classes: SF1, SF2 and SF3 measures 550-650, 660– 750 and 760– 850 mm, separately [12, 11 & 13]. H.Y. Leung et al [8] conducted a Sorptivity test on self-compacting concrete containing two mineral admixtures, silica and fume fly ash. Concluded that, SCC containing fly ash; reduces the water content per unit at the initial stage; because of the filling of micro-pores by the admixtures. From the literature [14, 15, 16 & 17], addition of steel fibers improves the tensile behavior of concrete. RafatSiddique et at.[18] conducted an experimental evaluation on fly-ash based fiber reinforced self-compacting concrete; F-class fly ash and hooked ended steel fibers has been used for effective result. Split tensile, compression, flexural, young’s modulus tests has been carried to evaluate the mechanical properties. porosity, rapid chloride permeability, ultra sonic pulse velocity tests has been conducted for determining the durability properties[20] and fresh concrete tests like slump flow, V-funnel, L-box, U-box carried out to study the rheological characteristics as per EFNARC guidelines [19] the concrete test has been conducted.

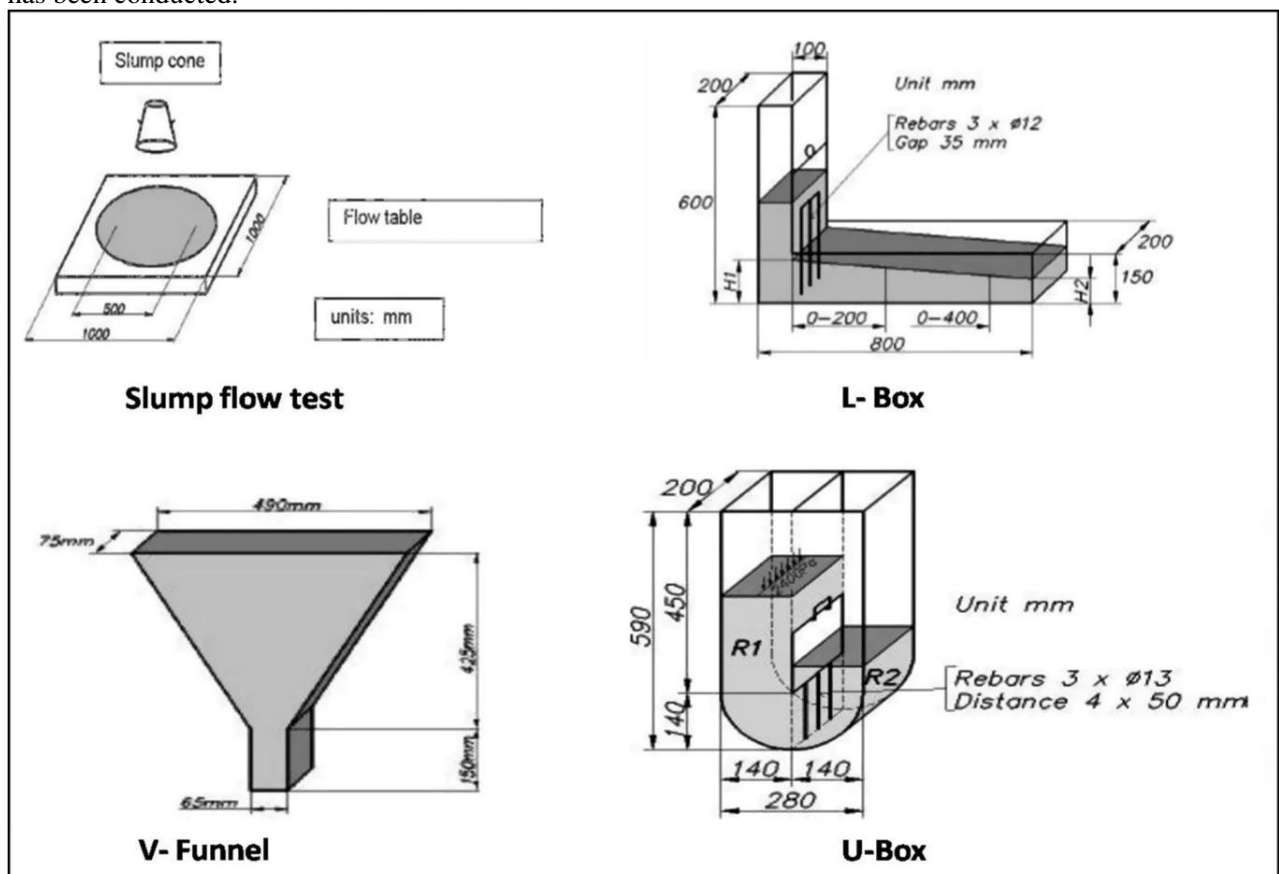
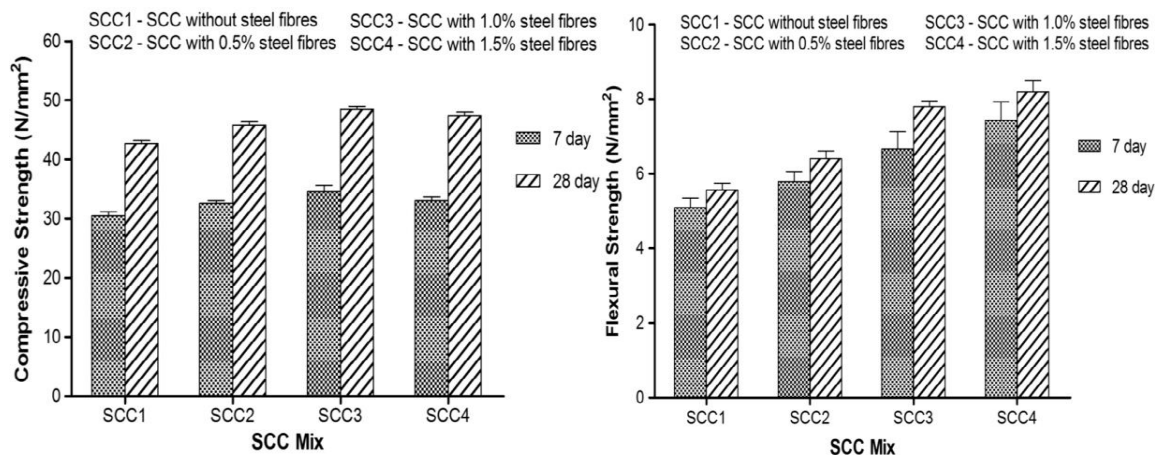


Figure 2. Schematic Layout of Fresh Concrete Tests [19].



Graph 1. Compressive and Split Tensile Strength [19].

Inference: it is clearly observed that increase in fiber ratio more than 1% the compression strength of the concrete is tend to decrease. There is eventual distribution of steel fibers up to 1% of fibers but there is fall of strength after 1%, it is because of improper bonding between the matrix composites. Concrete is good in compression so addition of fibers to enhance the compressive strength is notably trifling. Hence it is uneconomical. L.P.P.D. Oliveira et al. [21] and D.A.S. Rambo [22] determined that the percentage of fiber content there is directly proportional to the strength of the concrete but inversely proportional to the fresh concrete properties. There is an improvement in flexural strength up to 100% with addition of steel fibers up to 1% compared to conventional concrete. It was watched that higher the measure of steel FIBER in concrete, hoisted is the flexural strength and this was expected to arbitrary appropriation of steel strands in SCC which control the breaks and fasten them brought about expanding the heap conveying limit of prism examples [16].

4. Review on design and analysis of experiment; a statistical approach

The examination of a perplexing procedure requires the distinguishing proof of target quality traits that portray the yield of the procedure and of elements that might be identified with those characteristics. Once a rundown of potential elements is recognized from subject-matter mastery, the qualities of the relationship between those variables and the objective ascribes should be evaluated. A credulous, one-factor-at-a-time examination would require numerous a bigger numbers of trials than fundamental [104]. Designing experiments with particular design of experiments (DOE) is more proficient, complete, clever, and less error-prone than delivering the same design by hand with tables. Furthermore, it gives the capacity to produce algorithmic designs (as indicated by one of a few conceivable optimality criteria) that are every now and again required to suit imperatives regularly experienced practically speaking. Once an experiment has been designed and executed, the investigation of the outcomes ought to regard the suspicions made amid the design procedure. For instance, split-plot experiments with hard-to- change components ought to be investigated in that capacity; the limitations of a blend design must be consolidated; non-normal reactions ought to either be changed or displayed with a summed up direct model; relationship between rehashed perceptions on an experimental unit might be displayed with irregular impacts; non-constant fluctuation in the reaction variable across the design elements might be demonstrated, and so forth. Software for dissecting designed experiments ought to give these abilities in an available interface.

Mohammed Sonebi et al. developed a statistical model to investigate medium strength self-compacting concrete (MS-SCC). Five important key parameters were considered that has an influence on filling ability, segregation, passing abilities and mechanical properties of concrete. Pulverized fuel ash (PFA)

was used as a filler material. The key materials were cement and PFA, water-to-powder (cement + PFA) ratio (W/P) and dosage of SP. Responses were derived for ten parameters: Orimet time, JRing combined to cone, fluidity loss, slump flow, V-funnel time, segregation, JRing combined to the Orimet, rheological parameters, L-box and compressive strength at 7, 28 and 90 days [105].

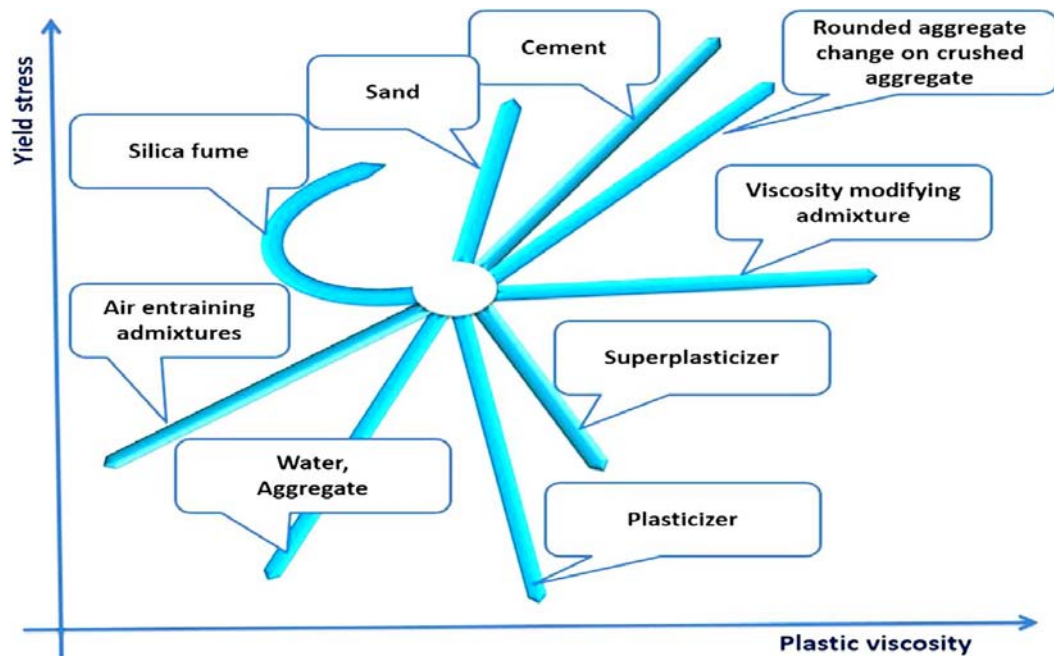


Figure 3. Schematic representation of factors influencing concrete mix on rheological properties [106-110].

From the schematic diagram it has been found that there is a plenty of information that influencing the composition on the rheological properties; addition of silica fume up to 12–17% of total weight of binder results in reduction in plastic viscosity of mixture, and the effect is much higher than the greater the total quantity of the additive [105]. Higher flowability of the fresh cement SCC (expanding of the diameter of slump flow and diminishing the slump flow time – reduction in yield stress and plastic viscosity) is gotten by expanding the w/b ratio, lessening the volume of cement and utilizing rock aggregates rather than pulverized aggregates. Be that as it may, the prerequisites for the organization HPSCC to acquire high compressive strength. This can be acquired by designing: low w/b ratio, higher substance of cement with higher than the normal evaluation and high surface area, utilization of mineral added substances, particularly silica fume also, utilization of pulverized aggregates collaborate in the inverse way, however in this way diminishing workability [105-110].

Aleksandra Kostrzanowska-Siedlarz et al. [105] developed design of experiments (DOE) to produce a high performance self-compacting concrete, considering the factors that Influence of the composition on rheological properties represented using statistical model. The statistical model developed highlights the relative roles of the elements of mix design proposed. From the result it is concluded that the cement paste content and w/b ratio are there only two significant parameters of the mix design due to the appropriate rheological properties. After analyzing the literature of [113-119] the levels of factors and the variable that influencing the performance of high performance self-compacting concrete were fixed; the statistical output is analyzed after conducting a literature survey were carried out; shown in table 5(Summary of Statistics for a Typical Composition of fiber reinforced high performance self-compacting concrete(FRHPSCC) containing admixture).

Table 5.Statistical Typical Composition of FRHPSCC

Sl.No	Independent variable	Response variable limitations	median	Responses(dependent variable)
1	Total binder content	350kg/m ³ -600 kg/m ³		Compression strength
2	Water to binder ratio	0.31-0.53		Split tensile strength
3	Percentage of mineral admixture	7.5%-25%		Flexural strength
4	Percentage of SP	0.5%-2%		Young's modulus
5	Percentage of steel fibers	0.25%2%		Cost per cubic meter

5. Summary of existing works on frscc and statistical modeling

Authors	Year	Description	Binder	w/B	Mineral Admixtures	Chemical Admixtures
M. Ghanooni-Bagha et ai [134]	9-Mar-16	No significant relation between strength and corrosion. When crack width was increased by about 1mm (which reflects 7-12% corrosion in rebar's) compressive strength dropped	88 Kg/m ³	0.40	SF=32 Kg/m ³ MK=80 Kg/m ³ SL=200 Kg/m ³	sp=0.63 % of cement wt

		by about 20%.			lime stone powder=170 Kg/m ³	
Hai-Thong Ngo[7]	22-Feb-16	(w/P), SP and the use of viscosity agent have significant effects on the total binder consumption during the mixing.	300 Kg/m ³	0.60	limestone filler=120 Kg/m ³	sp=6.6 l/m ³ vma=1 l/m ³
H.Y.Leung[8]	16-Mar-16	Use of silica fume and fly ash reduces water content and improves durability properties and increases the 28-day cube strength. But there is no relation between the compressive strength and the sorptivity in SCC achieved.[3]	372kg/m ³	0.38	SF=93Kg/m ³ FA=155Kg/m ³	sp=4.1 l/m ³ vma=14.33 l/m ³
GuilhermeChagasCordeiro[11,13]	09-Dec-15	The fiber reinforced concrete has increased the tensile properties. Adequate thermal insulation properties also improved when compared to normal concrete. Moreover, autogenously shrinkages were reduced. concretes with fine lightweight aggregates showed higher drying shrinkage than the coarse lightweight aggregate.[4]	329kg/m ³	0.37	AE0500=234 Kg/m ³ AE1506=280 Kg/m ³	sp=8.9 l/m ³ vma=0.01 l/m ³
Muhammad N.S. Hadi[135]	26-Feb-16	Results showed, there was no slippage and fracture at the ends of the specimens and also the failure was in the middle of specimens. The direct tensile strength showed lower strength than the flexural and splitting strengths.[5]	280kg/m ³	0.41	slag=50Kg/m ³ FA=120Kg/m ³	sp=3.375 l/m ³
GurwinderKaur[18]	20-Nov-15	The workability of hooked end steel fibre reinforced SCC with 0.5% and 1.0% by volume, found to be in the range set by EFNARC and reduced when increase in fibers up to 1.5%. Eventually led to decrease in rheological properties prescribed by EFNARC and ACI 237 R. The enhancement of strength is because of bond strength of steel fibers and pore refinement by FA. The tensile property is directly proportional to fibers content. Increase in fibre content affects the rheological properties in SCC [6]	450kg/m ³	0.41	FA%=10 FA=50Kg/m ³	sp%=1.2 sp=6 l/m ³ steel fiber%=1.5 steel fiber=105 kg
B.L. Karihaloo[127]	15-Feb-16	The vital crack opening are over looked by the volume of coarse aggregate in the matrix mix. The larger the coarse aggregate volume the critical crack opening (wc). But the mix grade	367.5 Kg/m ³	0.47	GGBS=122.5 Kg/m ³ limestone powder=172 Kg/m ³	sp=2.8 l/m ³

		inversely proportional to the crack opening (wc).[7]				
Ta-Peng Chang[136]	22-Dec-15	SCC with 30% replacement of Fly Ash produced the compressive strength of 40-60MPa. With excellent fresh concrete properties and enhanced mechanical and durability properties[8]	0	0.3 0	GGBFS =330Kg/m ³ FFA =141Kg/m ³ CFA=71Kg/m ³	sp=1.9 l/m ³
Süleymanİpek[122]	26-Apr-16	Water/binder ratio plays a significant role in initial and final setting time of SCC, in addition to the slump flow diameter and V-funnel flow. Increasing the artificial lightweight aggregate content systematically reduced the mechanical properties of concrete [9].	360Kg/m ³	0.4 4	FA=120Kg/m ³	sp=6.2 l/m ³
Khalid B. Najim[137]	18-Nov-15	Replacement of CEMENT KILN DUST (CKD)more than 30%reduced the durability and mechanical properties of SCC. Eventually high strength SCC could be produced with up to 20% wt. CKD replacement while high The conclusion is that CKD can be used as a replacement for cement material in developing high strength /performance SCC with good rheological properties [10].	315 Kg/m ³	0.4 2	CKD=135Kg/m ³	sp=11 l/m ³
Wenwei Wang[138]	9-May-16	The study showed salt freeze-thaw cycles leads to weight loss and the dynamic elastic modulus is declined. The coupling effect reduces the surface erosion. The predictive models has been developed using the experimental data achieved in the study and these modelsare used to predict the damage degree of SCC under coupling effect due toflexural load and salt freeze-thaw effect [11].	283 Kg/m ³	0.3 5	FA=66 Kg/m ³ Blast furnace slag=89 Kg/m ³ SF=22 Kg/m ³	sp=5.98 l/m ³ Air-entraining agent=0.032 l/m ³
SamanSolei manıKutana ei [139]	3-May-16	The study showed thatfiber reinforcement improves the mechanical properties but decreases the workability of the SCC with increasing volume of fiber. However, steel fibers have greater performance with relation to mechanical properties than polyphenylene sulfide fibre.[12].	413.1 Kg/m ³	0.4 0	lime stone powder =288.8 Kg/m ³ steel fiber =0.4%	sp=7 l/m ³
S. Kothandaraman [140]	11-May-16	Utilization of controlled penetrable formwork (CPF) liner is one of the procedures utilized to enhance the	435 Kg/m ³	0.4 8	FA=100 Kg/m ³	sp=5.4 l/m ³ vma=1

		nature of the surface of the cement. CPF liner Channels blend water and ensnared air from the closed surface of cement while holding the bond and other fine particles. The test outcomes uncover that CPF liner performs similarly well with SCC. Vibration/hydrostatic weight may not assume important part in depleting the interface water through CPF line [13].			l/m^3
HaticeÖznur Öz[122]	11-Apr-16	The fresh SCLCs have better passing ability, fluidity, uniform distribution of aggregate and resistance towards segregation. Incorporating treated coarse LWAs increased the workability characteristics of SCLCs. However, appreciable improvement in the consistency of SCLCs by nS addition was observed. The SCLCs made with treated LWAs and 5% nS were found to be the harder samples in this research.[14]	315 Kg/m^3	0.5	FA=112.5 Kg/m^3 Nano silca =22.5 Kg/m^3 LWA(4-16)mm =529.2 Kg/m^3 LWA(2-4)mm =262.8 Kg/m^3 Natural aggregate(0-2)mm =360.0 Kg/m^3
Jiangxiong Wei[141]	25-Mar-16	The shrinkage of SCCs was significantly influenced by the restraint and H_{MCT} of coarse aggregate. The shrinkage of SCCs increased with the decrease of coarse aggregate volume, which is because of the increment of H_{MCT} . Further, the maximum tensile stress induced by the aggregate restraint was calculated based on the elasticity theory. aggregate size is directly proportional to theoretical elastic stresses and aggregate restraint coefficient on the mortar.[15]	329 Kg/m^3	0.5 0	FA=62 Kg/m^3 GBFS=82 Kg/m^3
ErhanGüney isi[123]	16-Mar-16	The influence of RCA replacements on the shear thickening behavior of SCC was explained by analyzing rheological properties. The slump flow and T500 time, V-funnel time and L-box height ratio tests were carried out to identify the effects of both CRCA and FRCA utilizations on the fresh properties of SCC. The results reveal that Herschel-Bulkley and modified Bingham models provide well defined rheological representations for SCC with RCA. The self-compatibility characteristics of the concretes are remarkably improved by the	440 Kg/m^3	0.4	FA=110 Kg/m^3 CRCA=734.6 Kg/m^3 FRCA=691.79 Kg/m^3 sp=6.88 l/m^3

replacement levels of CRCA and FRCA used in SCC mixtures.[16]

Aleksandra Kostrzanowska-Siedlarz[105]	5-Apr-16	HPSCC is characterized by its rheological properties. These properties are critically influenced by the timing of the casting process. Using rheometry, the links between slump flow (yield stress σ), slump flow time (plastic viscosity η) and composition of HPSCC mix and time are investigated. We conclude that the cement paste content and w/b ratio are there only two significant parameters of the mix design due to the appropriate rheological properties.[17]	518.8 Kg/m ³	0.3 1	CSF=273 Kg/m ³	sp=16.4 l/m ³
Sofia Aparicio[142]	9-Dec-15	It was found that the samples cured at 70% humidity present more tetrahedrally coordinated aluminum since more aluminum is taken up by the CASH gel and the transformation of ettringite to AFm is promoted. The samples cured at 98% humidity are more hydrated but present lower mean chain lengths of the C-S-H gel.[18]	231.7 Kg/m ³	0.5 3	white limestone sand=876.1 Kg/m ³ limestone gravel=895 Kg/m ³ limestone filler=154.5 Kg/m ³	sp=3.2 l/m ³
Cristina Frazão[124]	12-Jan-15	The study showed that, the addition of steel fibers to SCC was very effective. In which the post-cracking flexural resistance and the energy absorption increased at greater extent, and did not affect significantly the self-compacting requisites and the durability of SCC.[19]	413 Kg/m ³	0.3 1	limestone filler=353 Kg/m ³ steel fiber=60 Kg/m ³	sp=7.83 l/m ³
Rahmat Mandoust[125]	3-June-15	The values showed that the volume fraction of steel fibers and mixture characteristics can significantly affect the fresh and hardened properties of SCC.[20]	500 Kg/m ³	0.4 5	limestone filler=110 Kg/m ³ steel fiber=80 Kg/m ³	sp=3 l/m ³
Sherif Yehia[143]	22-May-16	it was watched that introduction of Fiber-Reinforced Self-Compacting Concrete (FRSCC) to early wet/dry cycles enhanced the mechanical properties of all blends; an expansion in compressive quality of 10 MPa contrasted with non-exposed examples was tested. The micro structure of Synthetic Fiber-Reinforced Self-Compacting Concrete (SyFRSCC) and Steel Fiber-Reinforced Self-Compacting Concrete (SFRSCC) was	409.5 Kg/m ³	0.4 5	synthetic fiber=2.3 Kg/m ³ steel fiber=19.4 Kg/m ³	sp=7 l/m ³

		unique, which clarifies the distinction in their particular crack-resistance components.[21]			
Claudia P. Ostertag[133]	11-Dec-15	The presence of hybrid fiber reinforcement is shown to provide an improvement to the phenomena of internal confinement and tension stiffening, for compression and tension loading respectively, which allow for a significantly improved post cracking response.[22]	397 Kg/m ³	0.45	FA=131 Kg/m ³ steel fiber=0.013 Kg/m ³ PVA=0.002 Kg/m ³ sp=0.93 l/m ³ vma=2.2 l/m ³
S.P. Singh[146]	12-May-14 14-V4	The flexural fatigue performance of SCC as well as SFRSCC was found to be better than the conventionally vibrated concrete (CVC) and fiber reinforced concrete (CVFRC). This may be due to the fact that SCC contains large proportions of finer particles and does not need mechanical vibrators for compaction, which results in a denser and more homogenous concrete compared to CVC.[23]	410Kg/m ³		FA=205Kg/m ³ steel fiber=1% sp=2.2% of cement wt vma=0.35% of cement wt
Elias MolaeiRaisi [145]	31-Oct-13	The results revealed that the workability of medium and high strength SCC classes is reduced by increasing the steel fiber volume fraction, and using high percentages of fibers led to decrease of other rheological characteristics that have been specified by EFNARC and ACI 237R. On the contrary, splitting tensile strength, flexural strength, and flexural toughness are increased by increasing the percentage of fibers; however compressive strength is decreased by increasing the percentage of fibers.[24]	500 Kg/m ³	0.38	SF=50 Kg/m ³ Filler=200 Kg/m ³ steel fiber=2% sp=7.5 l/m ³ vma=4l/m ³
Mohamed I. Abukhashaba [144]	12-Mar-14	shrinkage was reduced using PPF and f_c of SCFRC was significantly affected by C_f and L_f . The higher the C_f , the higher the obtained f_c and improved by 15.3–25.6% using various C_f . Strength decreased from 1.29 to 1.14, 1.09, and 1.12 using PPF of 0.005, 0.010, and 0.015 kN/m ³ . PPF and CKD could be successfully used in SCC production in spite of its slightly negative effect on workability and a higher dosage of superplasticizer is required to achieve similar flow properties. 25]	3.2 kN/mm ²	0.45	CKD=.8kN/m ² PPF=0.010kN/mm ² PPF length=60 mm sp=0.96l/m ³

6. Review on impact of FR-SCC

A. Pineaud et al (2016) [120] done an experimental study on high performance self-compacting concrete at room temperature and elevated temperature. The study was keenly concentrated on the mechanical properties, the specimens were studied at the elevated temperature of 600°C ; SCCs for the most part contain higher glue volumes, bigger substance of mineral admixtures also, often bring down fastener to water ratios than VCs. These particular structure parameters permit satisfying the difficult to-please fresh state prerequisites of SCCs. Be that as it may they could likewise adjust essentially their mechanical behavior when cement is submitted to high temperatures

ErhanGüneyisi et al (2016) [121, 122] has investigated the properties of self-compacting lightweight concrete (SCLC). Lightweight aggregates (LWAs) are developed from fly ash (90%) and cement (10%) by pelletizing (making in to balls). The combination of LWA and nano-silica (nS) showed higher blocking ratio. But higher viscosity was accompanied by using higher amount of nano silica addition. Treated LWAs improved SCLCcompressive strength and workability. Also studied the advantage of recycled concrete aggregate (RCA) in SCC. Fine and recycled coarse aggregates (RCAs) were replaced with natural aggregates at various levels. Effect of RCA on the rheological properties of SCC was studies. Various models were used to describe the rheological behavior of SCC with RCA. Herschel-Bulkley and modified Bingham models provided the better results for SCC.

Cristina Frazão et al (2014) [124] has investigated the durability properties of self-compacting concrete (SCC) with addition of steel fibers. Adding of steel fibers to SCC is very effective in the terms of mechanical and durability of concrete, by increasing the post-cracking flexural resistance, impact resistance and the energy absorption, without affecting significantly the self-compacting concrete requirements. The comparisons were made SCC and FRSCC.

RahmatMadandoust et al (2015) have done an experiment on the factors influencing the durable of steel fiber reinforced self-compacting concrete (SFRSCC) [125]. In this study the experimental program includes cement contents ranging from 400 - 500 kg/m³, two different sizes of coarse aggregate (10 and 20 mm) along with steel fiber with the volume fractions of 0% to 1% was taken. The w/c ratio was kept constant at 0.45 throughout the mix [126].Its observed that flexural strength, modulus of elasticity, and split tensile strength is directly proportional to V_f (volume fraction) up to threshold level of fibers.

Gonzalo Ruano et at (2015) have conducted a The numerical simulation of the mechanical behavior of a series of reinforced concrete beams which includes strengthened and repaired beams with high performance self-compacting SFRC tested under shear[127-132]. The assumption of fiber orientation in three orthogonal directions is acceptable [127].

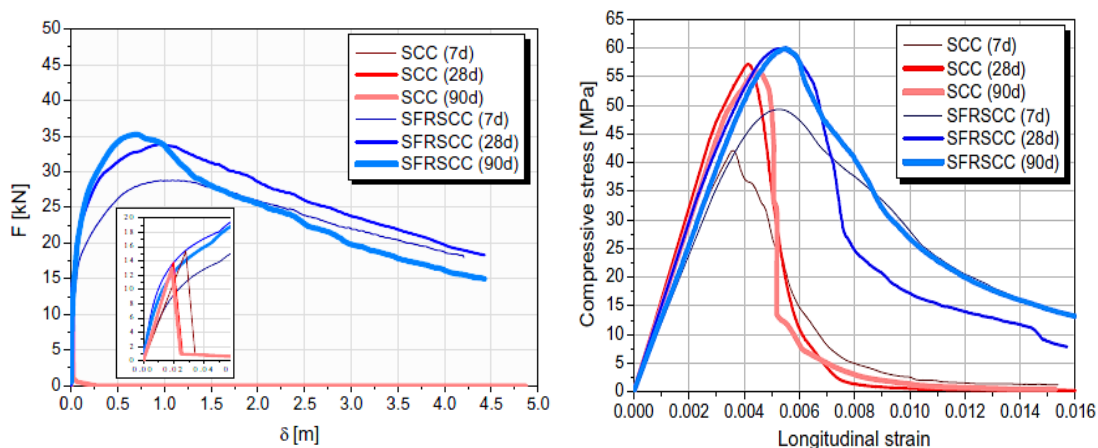


Fig 4. Compressive stress-axial strain and Flexural load-deflection relationships [124]

Inference: a pivotal strain level much higher than the strain at peak stress keeping in mind the end goal to decide the stress-strain reaction of the materials not just in the pre-peak yet, additionally in the post-peak stage. The addition of steel fibers has mainly contributed towards the increase of the residual compressive strength in the post peak phase of the material, with a favorable effect in terms of its energy absorption capability [124]. The addition of steel fibers in SCC increases the elastic modulus.

Gabriel Jen et al (2016) has created self-combining half breed fiber strengthened solid composite [133]. A self-solidifying subsidiary of HyFRC was created and has been appeared to be better than ordinary cement from numerous points of view. Research center scale applications have demonstrated that the material has unrivaled flowability and workability to such an extent that it can without much of a stretch out throughout thick formwork with little vibration required. Mechanical tests on unreinforced examples feature the maintenance of toughening instruments gave by both the VA microfibers and 30 mm steel microfibers as far as break control and split adjustment in spite of the whole substitution of 60 mm steel filaments found in HyFRC being required for stream and passing capacity qualities. Fiber strengthened cement (FRC) is blends of bond concrete containing short discrete, consistently scattered and arbitrarily situated appropriate sinewy material which builds its auxiliary trustworthiness. The measure of filaments added to solid blend is measured as level of the aggregate volume of composites. Aspect ratio (l/d) is calculated by partitioning fiber length (l) by its distance across (d).

7. Conclusion

Self-compacting concrete plays a vital role among overall economic growth both globally and locally. In current scenario; in order to develop a unique sustainable concrete considering the all prospectors, there is a need to update and understand the complete interactive effect of the many issues from cradle-to-grave in the design phase of concrete. This paper produce the complete knowledge on concrete and the current developments in self-compacting concrete, utilizing various dissipate materials like, fly ash, Metakaolin, base ash and other mineral admixtures and inclusion of several other fiberx material to make the concrete more sustainable. Researchers had developed a various modulus to study the factors affecting the performance of responses (compressive strength, split tensile, flexural strength, etc.) of the concrete. The detailed study has been carried out in key material properties and the factors influencing as well as affecting the concrete's durability, strength, etc. In order to safe excess loss of materials during the research work and also considering environmental aspects, several designs of experiments have been developed to reduce to number of trials. To achieve the exact mix proportion of variables and to predict

the responses with utmost accuracy. From the literature study it has been clearly seen that the present state of learning is not adequate to viably control the blends of admixtures with fibers as per rheological and mechanical properties. Hence the future study is to investigate the ideal blend outline and the impact of real change in greatest small scale micro-steel fiber and admixtures (fly ash and metakaolin) rate content on the properties Self-Compacting Fly-Ash concrete, likely termed to micro-steel fiber reinforced self-compacting concrete containing admixture. To develop a statistical module for the exact prediction of responses. The generated database will be advantageous for selection of best innovative material for production of good nature of SCC and additionally for further research work in this specific area.

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