Gaurav Kumar Singh (July 2022). Practical Investigation Of Steel Fiber Reinforced Self Compacting Concrete
International Journal of Economic Perspectives,*16*(7),88-96
Retrieved from https://ijeponline.org/index.php/journal

PRACTICAL INVESTIGATION OF STEEL FIBER REINFORCED SELF COMPACTING CONCRETE

Gaurav Kumar Singh, Research Scholar[1]
Mr. Sonu Mangla, Assistant Professor[2]
Vivekananda College of Technology and Management, Aligarh[1,2]

ABSTRACT

Technological foresight of concrete industries have let to the development of such special concrete. Concrete technology aims for concrete which have high quality, best performance, save time and economy. The major aims of this research are concept development and find the mechanical properties of SFR-SCC mix. Challenge faced in this research, is to find a proper mix design for mix proportion for SFR-SCC. Optimization of this mixes proportion such that workability and structural performance are enhanced.

Keywords:- SCC, compressive, flexural, tensile strength, flow ability

INTRODUCTION

Self compacting concrete is highly engineered concrete with higher fluidity get consolidated in form work without vibration and doesn't exhibit segregation and bleeding. This chapter emphasizes the details regarding the origin of Self Compacting Concrete (SCC), its different approaches in development of SCC, mix proportion of SCC and unique characterization of Self Compacting Concrete (SCC). When fibers is added to SCC matrix the mechanical properties are enhanced hence details of Fiber Reinforced Self Compacting Concrete (FRSCC) were also given to know effect of fiber in SCC. Mechanically anchored steel fibers have been proven as reinforcement, even for structural application. Thus, the steel fibers pick up the stresses quickly and affect the cracking process immediately. The long term load carrying capacity of the steel fiber reinforced concrete is significant. Hence the needs of investigation in Steel Fiber Reinforced Self Compacting Concrete (SFR-SCC) field were also discussed and ultimately objective of investigation in SFR-SCC is discussed briefly.

In recent decades Self Compacting Concrete is one of the emerging technologies in concrete technology field. Several attractive aspect of SCC, such as faster construction, smooth finish, reduced noise, thinner concrete section, increased durability, improved mechanical properties and aesthetics has kindled many researchers to venture into this field. Studies have been expanded to innovative programs, incorporating many new materials in SCC. Energy conservation is also done by use of SCC, as electrical requirement is eliminated while compacting and use of by product material such as fly ash quarry dust, etc.

The SCC was first proposed by Okamura in 1986. Ozawa has published his first paper on 1996. Ozawa and other three colleagues presented a paper on the same subject at an international conference on concrete held in Istanbul in 1992. This presentation has hindered many researches into this field. As a result many international workshops were conducted on SCC. Till date, no standardization has been done to design and evaluate properties of self compacting concrete. The performance of SCC has made many countries to adopt this concrete in construction industry. However, there is a need for conducting more research and development works for the measurement and standardization of the methods

Corresponding author: **Gaurav Kumar Singh**
Submitted: 27 March 2022, Revised: 09 April 2022, Accepted: 18 May 2022, Published: July 2022

or the evaluation of the self-compacting characteristics of SCC. SCC is more viscosity than normal concrete which in turn increases the workability. Increases in workability leads to increased segregation and reduction of entrained air voids and loss of entrained air voids. This problem needs to be considered very carefully while designing the SCC mix. SCC should be designed in such a way that is has balance between deformability and stability. Three major approaches to develop SCC are limiting the aggregate content; reduce the water to powder ratio and use of super plasticizers.

SCC contains same constituent materials as that of Vibrated Concrete (VC) such as cement, aggregate, water, chemical admixture and mineral admixtures. However, its mix proportion is varied to achieve flow ability without external energy, remain homogenous while flowing and fill up the reinforcement without any gap. The unique properties of SCC are flowing ability, filling ability, passing ability and segregation resistance. Flowing ability is the property of the concrete by which it flows easily through formwork. Filling ability is the rate of flow of concrete in formwork. Passing ability is the property of concrete by which it flows through reinforcement without segregation or blocking. Segregation resistance is the ability of concrete to remain homogenous in fresh stage. These four properties should not vary during transport and placing. Also these properties are interdependent. Change in a property may result in change in one or more properties. When filling ability and segregation are low it also results in insufficient passing ability.

SCC contains same components as that of Vibrated Concrete (VC) such as cement, aggregate, water, chemical admixture and mineral admixture, however, its mix proportion is varied to achieve flow ability without external energy, remain homogenous while flowing and fill up the reinforcement without any gap. The following constituents are used-

- Cement
- Fine Aggregate
- Coarse Aggregate
- Fly ash
- Fiber
- Chemical Admixture

FIBER REINFORCED SELF COMPACTING CONCRETE

When fiber is incorporated in concrete as a composite material, it is known as Fiber Reinforced Concrete (FRC). Concrete is a brittle material, with low tensile strength and possesses low stain capacity. Addition of fiber as composite material proves to be a solution to this problem. It forms a bridge across the crack and increases the ductility of concrete. Homogenous tensile concrete is obtained with the addition of steel fiber. Self Compacting concrete is well known for its performance in its fresh stage but in hardened stage it has low tensile strength and shear strength. When fiber is reinforced in self compacting concrete this problem is solved. Such type of concrete is known as Fiber Reinforced Self Compacting Concrete (FRSCC). Structural performance of SCC is increased. All types of fibers can be added in cement matrix but its aspect ratio and volume of fiber in concrete affect the workability of SCC. Hence special care has to taken in mix proportion of FRSCC.

Corresponding author: **Gaurav Kumar Singh**
Submitted: 27 March 2022, Revised: 09 April 2022, Accepted: 18 May 2022, Published: July 2022

LITERATURE REVIEW

Sallal R. Abid,* Munther L. Abdul-Hussein, Nadheer S. Ayoob, Sajjad H. Ali, and Ahmed L. Kadhum (2020) Concluded for similar fibrous SCC specimens exposed to different drop-weights and different drop-height, the absorbed impact energy showed continues decrease as the drop-weight or drop-height increase. This result is attributed to the accelerated deterioration of the material microstructure due to the exposure to higher repeated impact forces. High percentage developments in impact resistance were gained when micro steel fiber was added to the SCC mixtures. The percentage development increases as the fiber content increases regardless of the loading case and it was in the range of approximately 150–860% compared to plain specimens. The highest percentage development in impact resistance was obtained when the standard loading case of a drop-weight and drop-height of 4.5 kg and 450 mm was considered, while the percentage developments were approximately comparable when the other four loading cases were considered.

Petr Lehner, Petr Koneˇcný and Tomasz Ponikiewski (2020) The article evaluates durability related to concrete material parameters. There are relative values for cube and cylinder compression strength, tensile splitting strength, and modulus of elasticity. Three approaches are discussed for the computation of diffusion coefficient applicable to the numerical modelling of chloride ion ingress to concrete. Studied approaches are chloride profiling, electrical resistivity measurement, and rapid chloride permeability test. The comparison of the relatively fast method (resistivity and RCPT) for the evaluation of concrete ability to resist aggressive agents was conducted on the sample of self-compacting concrete. There was a correlation between the amount of steel fibres and conductivity, as expected. A larger amount of the steel fibres increases the calculated diffusion coefficient, both in electrochemical methods and in chloride profile evaluation. From this point of view, it is necessary to investigate, for example, porosity in further research. It needs to be proved if it causes some worse mechanical properties and, on the contrary, may tend to increase the results of all diffusion values (reducing the resistance against chloride penetration).

Chalioris (2020), Geogrid is a polymeric material that has a new use in concrete reinforcement. Using geogrid leads to an increase in concrete ductility and improves its ductile behavior in the same manner of using the different fiber-reinforced polymers (FRP) materials. Many researchers introduced the behavior of concrete elements reinforced or strengthened with many types of FRPs like carbon and glass fibers as wraps and sheets.

Priya P (2017) it has been observed that the Compression strength, Split tensile strength and flexural strength is improved 5.3%, 12% and 18% respectively. Deflection in fiber beam is less when compared to control beam. At load of 65 kN, the deflection for control beam is 9.42 mm where as in fiber beam deflection is 5.51mm. Addition of glass fibres reduces bleeding and it improves the surface integrity of concrete. Also it increases the homogeneity and reduces the probability of cracks.

Itani, et al. (2016) used uniaxial geogrid thin concrete overlays to test their effectiveness in preventing cracking. The test results showed that after cracking concrete was assisted by geogrids with ductility and extra load capacity.

Al-Hedad, et al. (2017) tested slab and beam samples reinforced with biaxial geogrid sheets to consider the impact of geogrid use on concrete pavements' drying shrinkage behavior. Test results showed that, compared to plain concrete samples, geogrids decreased the drying shrinkage strains by 7%–28%.

Corresponding author: **Gaurav Kumar Singh**
Submitted: 27 March 2022, Revised: 09 April 2022, Accepted: 18 May 2022, Published: July 2022

Uniaxial, biaxial and triaxial geogrids were used by El-Meski and Chehab (2014) to stabilize concrete beams samples subjected to four-points loading. For all geogrid-reinforced samples, a much higher deflection was observed, indicating a ductile post-cracking behavior comparable to the load-deflection patterns of reinforced geogrid and plain concrete beam.

Sandra Nuneset al. (2013) used central composite to design SCC mixture. Five factor was used in study (xl)water to powder volume ratio (Vw/Vp);(x2) filler to cement weight ratio (wf/wc);(x3)superplasticizer to powder weight ratio (SP/p);(x4) sand to mortar volume (Vs Nm)and (x5) solid volume (Vap). The effect of each factor was evaluated at five different levels a, -1, 0, +1,+a. Commercial software (Design-Expert) was used to analyze the results for each response .A Backward elimination was used in this work to eliminate non-significant terms in the regression model. The bootstrap technique to the original data sample the robustness value can be accurately estimated and the accuracy of this estimate can be assessed.

Guru Jawaharet al. (2012) have developed user friendly tool for mix design of SCC mixes (“JGJ_SCCMixDesign.xls”). It helps in displays of all necessary data required for SCC mix design and also displays constituent materials required for SCC.

Kishor Sable (2012) has conducted experiment studies to find the effect of aspect ratio and types of steel fibers were varied but volume fraction of fibers is kept constant on mechanical properties of self compacting concrete. The result shows that flexural strength of concrete with HK 80 steel fiber is higher than all other types of fiber.

Abdullahi et al. (2011) worked on modeling of light weight concrete mixture using palm oil clinker. A central composite method was used for factor setting. Three factors were selected for this work. Water cement ratio (x1) cement content by weight (x2) and fine aggregates to total aggregates ratio by volume (x3). Mini tab 14 was used for factor setting and the optimum mixture was found out. Experiments on a total of 20 mixtures were carried out to find slump, air density and strength.

Almeida et al. (2010) have studied the mechanical properties of SCC. The result showed that 3 series of SCC presented the behaviour similar to the conversional concrete, with a confidence interval of 95%. The variability was lesser than 10%, except for the tension strength. The bond resistance was not affected by the SCC’s lack of fluidity. However, according to the observations, the aspect of the beams cast with this specific concrete was characterized by the presence of voids and high porosity in the surface. The size of coarse aggregate (depending on its origin) has a strong influence in the bond resistance, since it affects the SCC elasticity modulus.

Corresponding author: **Gaurav Kumar Singh**
Submitted: 27 March 2022, Revised: 09 April 2022, Accepted: 18 May 2022, Published: July 2022

FRESHAND HARDENED PROPERTIES OF SFR-SCC BEAMS

TABLE 1 BEAM STRENGTH RESULTS

Mix ratio designation	Fiber combination ratio (AR1:AR2)	Slump flow (mm)	V - funnel (Sec)	SI ratio	PR ratio	Compressive strength at 28th day kN/mm²	Flexure strength at 28th day kN/mm²	Split tensile strength at 28th day kN/mm²
M-B1	0/0	850	7.50	14.75	0.93	76.50	7.20	4.30
M-B2	0/100	786	6.00	11.75	0.93	71.43	7.83	4.54
M-B3	25/75	762	6.66	11.93	0.92	72.68	7.99	4.56
M-B4	32/68	790	7.00	12.10	0.93	74.50	7.80	4.60
M-B5	50/50	811	7.03	12.40	0.89	75.82	7.30	4.96
M-B6	75/25	823	7.20	12.03	0.90	76.89	8.02	4.53
M-B7	100/0	831	7.31	13.00	0.93	72.21	7.88	4.65

FLOWING ABILITY

Slump flow test is used to verify this property and the readings are tabulated in Table 1. These readings show that the addition of steel fiber seems to restrict the flowing properties by 6 %. When the flowing property of AR2 fibers is compared to AR1 steel fiber, AR1 seems to have 5%better flowing properties. The average flow mix with steel fiber was 772 mm. Only M-B3 falls under the SFI category while all other six beams belong to SF2 as indicated in Figure 1.

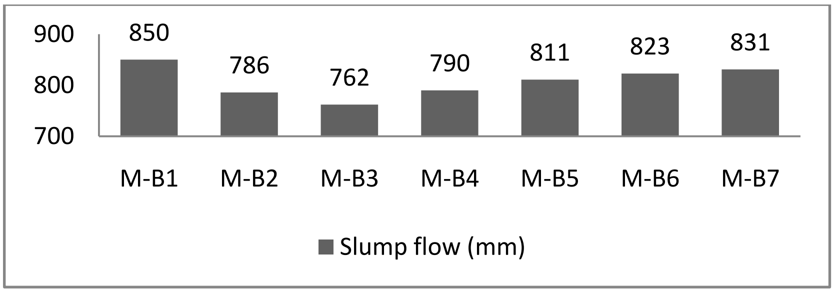

FIGURE 1 SLUMP FLOW TEST FOR SFR-SCC BEAM MIX PROPORTION

FILLING ABILITY

V-funnel test is performed and their readings are tabulated in Table 1. The filling ability is decreased by about 8 % with addition of fiber. Filling properties was 21% more than long steel fibers. Viscosities of all the mix were all high and all the mixes belong to VF1 as shown in the Figure 2.

Corresponding author: Gaurav Kumar Singh
Submitted: 27 March 2022, Revised: 09 April 2022, Accepted: 18 May 2022, Published: July 2022

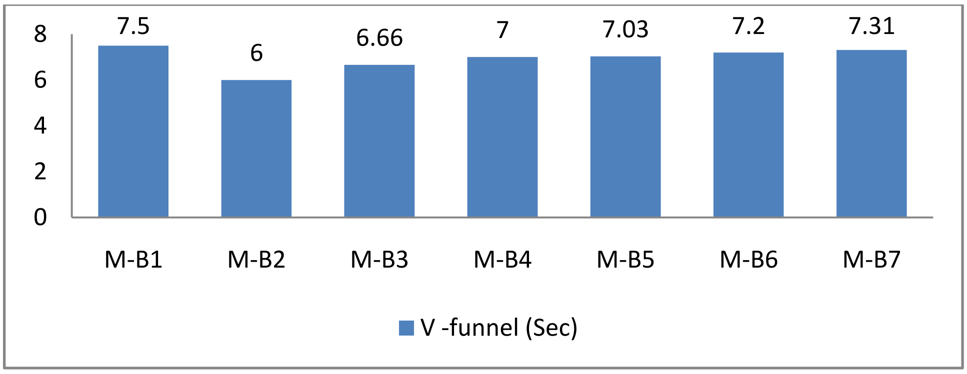

FIGURE 2 V- FUNNEL TEST FOR SFR-SCC BEAM MIX PROPORTION

PASSING ABILITY

L-box test is performed and their passing ratio values are found. Readings are tabulated in column 5 in Table 1. The passing ability decreased by about 1.4% with the addition of fibers. The passing ability was high in all mixes and all the mix belongs to PR2 as shown in Figure 3.

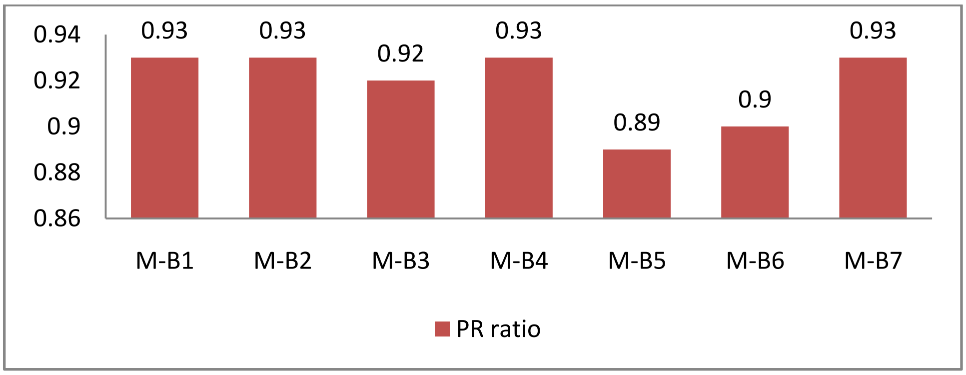

FIGURE 3 PASSING RATIO TEST FOR SFR-SCC BEAM MIX PROPORTION

SEGREGATION RESISTANCE

Wet sieve segregation test is performed and segregation index values are found out and are shown in the Table 1 under the column SI. Segregation resistance is decreased by about 17% with addition of fibers as shown in the Figure 4.

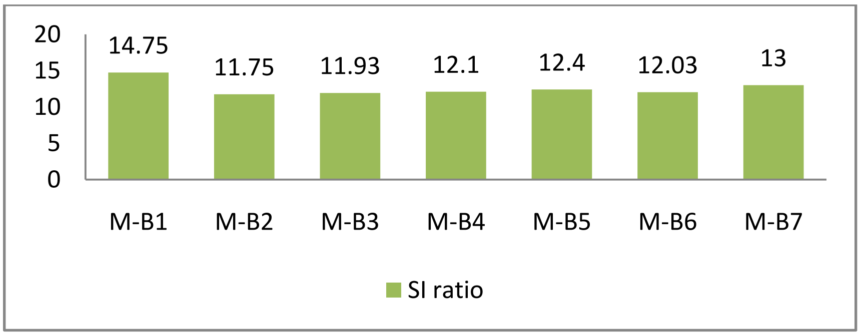

FIG. 4 SEGREGATION RESISTANCE INDEX TEST FOR SFR-SCC BEAM MIX PROPORTION

Corresponding author: **Gaurav Kumar Singh**
Submitted: 27 March 2022, Revised: 09 April 2022, Accepted: 18 May 2022, Published: July 2022

COMPRESSIVE STRENGTH

The average compressive strength of all the mixes was found to be 74 MPa at 28thday. The values show that the compressive strength has increased by 3 % with addition of fibers as shown in the Figure 5.

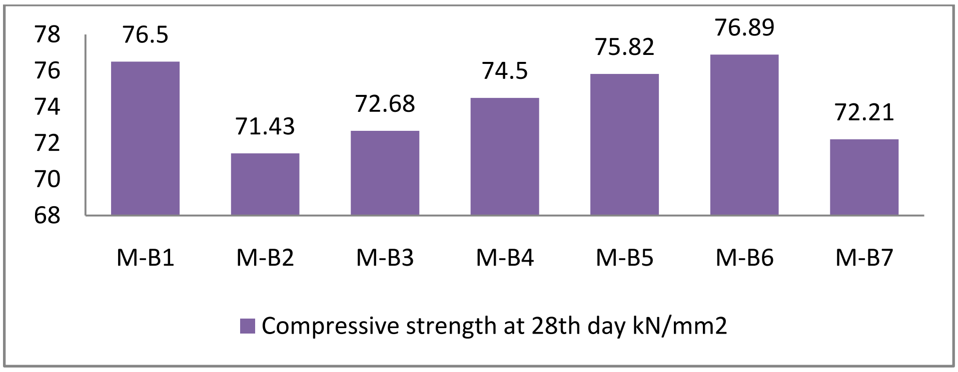

FIGURE 5 COMPRESSION STRENGTH TEST FOR SFR-SCC BEAM MIX PROPORTION

FLEXURAL STRENGTH

The flexural strength values are shown in the Table 1. It is observed that the average flexural strength is 7.17 MPa. Flexural strength increased by 8 % with addition of fibers, as compared to plain concrete mix as indicated in Figure 6.

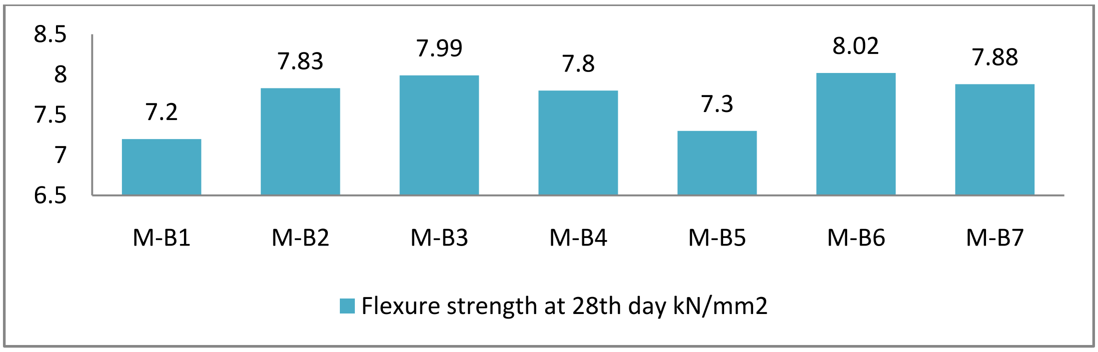

FIGURE 6 FLEXURAL STRENGTH TEST FOR SFR-SCC BEAM MIX PROPORTION

SPLIT TENSILE STRENGTH

Average split tensile strength is 4.5 MPa. The increase in tensile strength of 7 % is observed in FRSCC as shown in Figure 7.

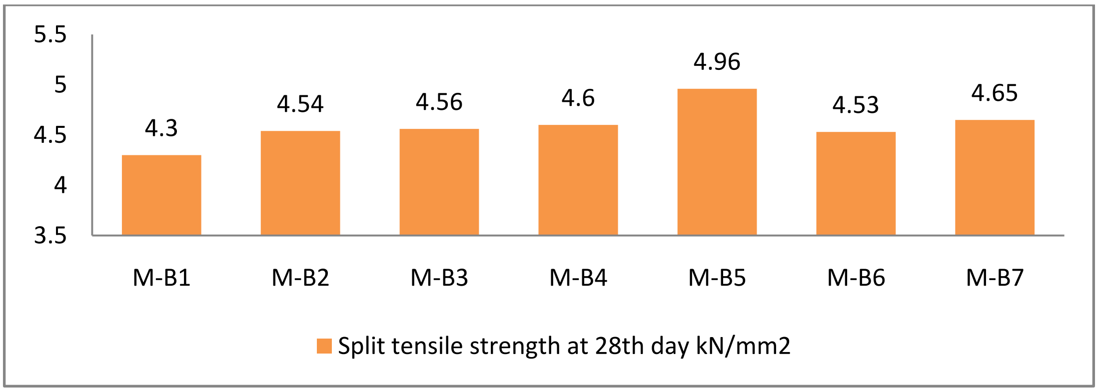

FIGURE 7 SPLIT TENSILE TEST FOR SFR-SCC BEAM MIX PROPORTION

Corresponding author: Gaurav Kumar Singh
Submitted: 27 March 2022, Revised: 09 April 2022, Accepted: 18 May 2022, Published: July 2022

Structural behaviors of these SFR-SCC beams were presented in this chapter. Beams were tested under half cyclic loading. The loading was applied to 70 to 80 % of predicted ultimate load. Number of cycles depended on the strength of beam. RCC beams were able to withstand only 2 cycles while SFR-SCC beams were able to withstand 6 cycles. Deflection was found at the midpoint and at one third distance of the beam.

CONCLUSIONS

On the basis of experimental investigation the following conclusions is drawn,

- Statistical experimental design helps us to investigate the influence of selected range of combination of variables for the desired characteristics.
- The mathematical models for responses helps in predicate of proportion of various constitutes of concrete, by substituting the values in coded form, of the respective factor.
- The result shows that, productiveness of the polynomial regression model is satisfactory in modeling SFR-SCC mix.
- From the model predicted it is seen that volumes of fly ash and SP dosage play a major role in influencing workability of SFSCC, while fiber volume and fiber combination play their major role in hardened properties of SFR-SCC.
- Higher energy dissipation was observed in the case of SFR-SCC beams.

REFERENCES

- Ozawa, K, Maekawa,K, Kunishima,M & Okamura, H 1989,'Development of High Performance Concrete Based on the Durability Design of Concrete Structures', In Proceedings of the Second East-Asia and Pacific Conference on Structural Engineering and Construction(EASEC-2), vol. 1, pp. 445-450.
- Ozawa, K, Tagtermsirikul,S&Maekawa, K 1992,'Role of Materials on the Filling Capacity of Fresh Concrete', In Proceedings of the Fourth CANMET and ACI International Conference on Fly Ash, Silica Fume, Slag and Natural Pozzolans in Concrete, American Concrete Institute, pp. 212-137.
- Sallal R. Abid,* Munther L. Abdul-Hussein, Nadheer S. Ayoob, Sajjad H. Ali, and Ahmed L. Kadhum "Repeated drop-weight impact tests on self-compacting concrete reinforced with micro-steel fiber", Heliyon. 2020 Jan; 6(1): e03198. Published online 2020 Jan 10.
- Priya P "Experimental Study on Flexural Behaviour of Glass Fiber Reinforced Concrete Beam using Self Compacting Concrete", VOLUME 06, ISSUE 06 (JUNE 2017)
- Chalioris, C.E.; Zapris, A.G.; Karayannis, C.G. U-Jacketing Applications of Fiber-Reinforced Polymers in Reinforced Concrete T-Beams against Shear—Tests and Design. Fibers 2020, 8, 13.
- Itani, H.; Saad, G.; Chehab, G. The use of geogrid reinforcement for enhancing the performance of concrete overlays: An experimental and numerical assessment. Constr. Build. Mater. 2016, 124, 826–837.
- Al-Hedad, A.S.; Bambridge, E.; Hadi, M.N. Influence of geogrid on the drying shrinkage performance of concrete pavements. Constr. Build. Mater. 2017, 146, 165–174.
- El Meski, F.; Chehab, G. Flexural behavior of concrete beams reinforced with different types of geogrids. J. Mater. Civ. Eng. 2014, 26, 04014038.

Corresponding author: Gaurav Kumar Singh

Submitted: 27 March 2022, Revised: 09 April 2022, Accepted: 18 May 2022, Published: July 2022

- Petr Lehner, Petr Koneˇcný and Tomasz Ponikiewski "Comparison of Material Properties of SCC Concrete with Steel Fibres Related to Ingress of Chlorides" 20 March 2020
- Abdullah Mohsen Ahmed Zeyad and Abdullah Mustafa Saba 2011,' Influence of Fly Ash on the Properties of Self-Compacting Fiber Reinforced Concrete', Journal of Steel Structures & Construction,volume 3 ,Issue 1, 1000128.
- Almeida Filho, FM, Barragán, BE, Casas, JR & Debs, ALHC 2010, 'Hardened properties of self-Compacting concrete – A statistical approach', Constuct. Build. Mater, vol. 24, no. 9, pp. 1608-1615.
- Guru Jawahar, J,Sashidhar, C,Ramana Reddy &Annie Peter, J 2012,'A simple tool for self compacting concrete mix design', International journal of advances in engineering & technology, vol. 3, pp. 550-558.
- Kishor S. Sable & Madhuri K. Rathi2012,'Comparison of Self Compacted Concrete with Normal Concrete by Using Different Type of Steel Fibres', Journal of Engineering Research & Technology, vol; 1, Issue 6, pp. 01-06.
- Sandra Nunes, Ana Mafalda Matos, Tiago Duarte, Helena Figueiras & Joana Sousa-Coutinho 2013, 'Mixture design of self compacting glass mortar', Cement Concrete Compos., vol. 43, pp. 1-11.

***Corresponding author**:* **Gaurav Kumar Singh**
Submitted: 27 March 2022, Revised: 09 April 2022, Accepted: 18 May 2022, Published: July 2022