A CRITICAL REVIEW ON EXPERIMENTAL STUDIES OF STRENGTH AND DURABILITY PROPERTIES OF FIBRE REINFORCED CONCRETE COMPOSITE

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Abstract

Concrete is most widely used construction material. It is a major part of development in all countries especially in a developing country like India. Concrete plays very important role in the infrastructural development, concrete possess a very low tensile strength, limited ductility and little resistance to cracking. The abundant availability of raw materials, excellent strength and durability, low manufacturing and maintenance cost, versatility in forming various shapes and unlimited structural application in combination with steel reinforcement has made the concrete a common construction material. The growth and advancement in concrete technology has made the construction to reach at high level with superior construction techniques and methodologies. The present review paper mainly focuses on research papers carried in the field of fibre reinforced concrete, which includes experimentation studies, strength and durability properties, effect on fibres etc. The latest developments in fibre reinforced concrete have been emphasized in the present review paper. The literature papers collected are mostly concentrated on the review of published papers after 2010. The paper represents a complete collection of the studies carried out in the field of fibre reinforced composites. The review article would give an updated material for the researchers in the field of fibre reinforced concrete. Thus helps them to carry out the research related to fibres, fibre composite etc, and can furnish in their studies and help them to arrive at feasible outcomes.

***Keywords**: Concrete, Durability, Fibres, Technology, Strength, Review.*

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I. INTRODUCTION TO FIBRE

Concrete possess very low tensile strength. Cracks propagate with application of load, leads to brittle fracture of concrete. Micro cracks are formed in concrete during hardening stage. The new technology of using fibres made the invention of fibre reinforced concrete to overcome these problems associated with cement based materials such as low tensile strength, poor fracture toughness and brittleness of cementitious composites.

Inherent micro cracks and weak in tension are the shortcomings of conventional concrete thus recent years have witnessed the extensive use of fibres like glass, steel, carbon and poly-propylene etc. in order to meet the challenges of the rapidly growing civil engineering industry. Addition of such fibres increases fire resistance, impact, compressive, erosion, split tensile and flexural strength, durability, serviceability of concrete, fatigue, fracture and shrinkage characteristics, cavitations and reduces formation and propagation of micro cracks. Aim of this work is to present the information accumulated from various researches and to highlight the benefit out of using fibres.

A. TYPES OF FIBRES

1. Hooked end steel fibre
2. Wavy steel fibre
3. Undulated segment steel fibre.
4. Flat end steel fibre.
5. Crimped steel fibre.
6. Shotcrete steel fibre.
7. Stainless steel fibre.
8. Promix steel fibre.
9. MS steel fibre.
10. Polypropylene fibres.

B. ADVANTAGES OF FIBRES

Addition of fibres improves the following properties of concrete;

1. Fire resistance.
2. Compressive strength.
3. Split tensile strength.
4. Flexural strength.
5. Durability(Sorptivity)
6. Erosion strength.
7. Serviceability of concrete.

8. Fatigue characteristics.
9. Fracture characteristics.
10. Shrinkage characteristics.
11. Cavitations.
12. Reduces cracking and crack propagation.

II. EXPERIMENTAL STUDIES ON STRENGTH PROPERTIES

Many researchers have carried out experiments related to strength properties with addition of different types of fibres. Below are some recent research articles received in the region, in order to get clear picture and understanding of fibres.

The Experimental study [1, 4] found out the optimum dosage of crimped and hooked steel fibre as well as of glass fibre for the increase in the compressive strength, flexural strength and split tensile strength of M_{70} grade concrete. The optimum dose found was 1.5% and 1% for the steel fibre and glass fibre respectively. The % increase of compressive strength at 28 days for hooked end steel fibre compared to conventional concrete was 7.3%, crimped steel fibre with 6.08%, glass fibre with 4.3% similarly %increase in the split tensile strength for hooked end steel fibre was 4.54%, crimped steel was 2.27%. The experimental analysis by Kavita, Vikrant and Satish [2] aimed at exploring the feasibility of various metallic and synthetic fibres in M_{20} concrete. SFRC containing 0% and 0.5% of hooked end steel fibres and 0% and0.25% of alkali resistance glass fibre cut into 12mm length was studied without using any kind of admixtures. The experiment further validated that addition of 0.5%, 50mm length end (S2) steel fibre gave the maximum compressive and split tensile strength compared to others. It was also found true that use of steel fibres reduces more of brittleness of concrete than that of the glass fibre. The research paper [5] by Komal Chawla and Bharti Tekwani highlights the experimental investigations conducted on the use of glass fibre with the structural concrete. Cem-fill anti crack, high dispersion, and alkali resistance glass fibre of diameter 14 micron having the aspect ratio of 857 was employed varying in the percentage from 0.33 to 1% and the properties of FRC like compressive strength, flexural strength, toughness and modulus of elasticity were studied. Later it was vivid that toughness increased by 1157% when 0.67% of fibre content and 1.25% steel(12 mm) was used. Modulus of elasticity increased by 4.14%, similarly compressive strength increment was observed to be at 37% where as the increase in the flexural strength was found to 5.19%. An informatory paper accumulating the results of the researches conducted by the various researchers [7] gives the tabulated result in the increase of the compressive strength and flexural strength with the use of the varying percentage of steel fibre. A study conducted by Mazen Musmar [8] studies the strength properties of FRC of grades ranging from 20 to 102 MPa and derives a mathematical formula to predict the split cylindrical tensile strength of steel fibre reinforced concrete. The split tensile strength given by the mathematical equation is in good agreement with the experimental results. Using alkali resistance glass fibres and experimental investigation [9] was carried out to study the experimental effect on compressive, split tensile and flexural strength on M20, M30, M40 and M50 grades of concrete. With the use of the glass fibre increase in the surface integrity and its homogeneity and reduction in the probability of cracks was found. Also the percent increase in the compressive strength for the various grades of the concrete was found to be around 20 to 25 % whereas the percentage increase of flexural and split tensile strength at 28 days was observed from 15 to 20%. An experimental study on properties of FR self compacting concrete [10] by Pradeepa had various objective such as studying the flexural behavior of the self compacting concrete, comparing the fresh and hardened properties of FRSC concrete with conventional concrete and also to find the optimum dosage of the addition of the glass fibre and super plasticizer for self compacting concrete. The conclusion was drawn that the optimum dosage for the glass fibre was 1% and of that of super plasticizer was 1.25%. Compressive and split tensile strength was increased by 5.3 and 12 % respectively. Faraz Khan and Juned Ahmad [11] studied the properties of latex modified steel fibre reinforced concrete by using Styrene Butadiene Rubber (SBR) latex. Steel fibres used were 0%, 0.25%, 0.5% at an interval of 0.25% and the latex was varied with the 5%, 10%, and 15% to obtain the maximum strength. They arrived at the result that 1% dosage of steel fibre gave the optimum result increasing the fibre beyond this showed the gradual decrease in the compressive, split tensile and flexural strength. The combination of 1%+10% of steel fibre and latex gave the maximum flexural strength. Ramesh and Dr. Neeraja D. [13] studied on the effect of different fibres such as steel, polypropylene and glass having different fractions on RC beam. Crack pattern, initial cracking load, ultimate load carrying capacity, maximum deflection of the beam were studied for different percentage of fibre to find the optimum percentage for each kind of the fibre. It was clear from the investigation that FR beam helps to improvise various structural behaviors and at the same time it was also found that steel fibres are good at arresting the crack formation. They also outlined that bridging action of the steel is much better than other two fibres. Review on performance of GFRC by Shrikant M. [14] worked out and highlighted the research work carried by various researchers on the GFRC and concluded that overall cost is greatly reduced although initial being higher and the increase in the compressive, split tensile and flexural strength was almost 20 to 25%. Thus GFRC may be used for blast resisting structures and hydraulic structures like dams. As per the information accumulated by Shrikant Harle and Prof. Ram Meghe [15] it was finalized that alkali resistant glass fibres (Cem-FIL anti-crack HD) shows good results compared to other fibres. It was also concluded that flexural strength and split tensile strength increased to almost 15 to 20% and compressive strength increment was found to be around 20 to 25 %. Various test results were conducted on the cubes of various sizes with and without the use of glass fibres to indicate the difference in compressive strength and flexural strength [17] by Engg. Pashtiwan and Prof. S. S. Pimplikar. It was suggested that GFRC was good for tension and its compatibility with the concrete was one of the major reason that helps us to use it in our daily project it was also outlined that AR glass fibre can control shrinkage cracks more easily and it can be used as the alternative material of natural stone especially in those country where availability of natural stone is less. Impact resistance of fibre reinforced concrete (FRC) incorporated with steel fibres at various dosages was studied by G. Murali, A. S. Santhi and G. Mohan Ganesh [19]. The result of the experiments conducted showed that steel fibres (CF2-CF4 and HF5- HF7) at the optimum dose of 1.5% showed significant increase in the compressive strength. Impact energy was increased by 80%, 160% and 260% in case of crimped steel FRC(CF2- CF4) and it was increased by 100%,200% and 280% in hooked end steel FRC(HF5-HF7) when compared to PC. Impact energy of concrete was found to be slightly more when hooked end steel was used compared to crimped steel. The effect of steel fibre on some mechanical propertied of self compacting concrete was studied by Abbas AL-Ameeri [20] purposed to investigate the fresh properties of steel fibre SCC and the hardened properties. He drew to the conclusion that the flow ability as well as blocking ratios both decreases with the increase in steel fibre also the slump flow time and V-funnel flow time increase with the increase in steel fibre. It was also found that ultra sonic pulse velocity decreased with including steel fibre in SCC. Vikrant S. Vairagade and Kavita S. Kene [25] together studied experimentally on hybrid fibre reinforced concrete adding steel and polypropylene fibres and tried to find out about their synergy. The intent of the study was that the performance of these hybrid systems would exceed that induced by each fibre type alone. The conclusion drawn was increase in the percentage of steel fibre reduces the slump value and thus to maintain the constant value we had to increase the super plasticizer's dose. Compressive strength of S0.8P0.2 was the maximum and the split tensile strength of S0.8P0.2 itself gave the higher value. An experimental investigation on glass fibre reinforced high performance concrete with silica fume as admixture as done by Vaishali G Ghorpade [26]. In the experiment she partially replaced cement with the silica fume by 0%, 10%, 20%, 30% and glass fibres were added in the percentage of 0, 0.5, 1.0, and 1.5% to produce the high performance concrete. 14% was the increase in the compressive strength with the optimum dose that is addition of 1% of glass fibre and 10% of silica fume where as the percentage increase in the split tensile strength was 18% compared to conventional concrete without the use of glass fibre and silica fume. An analysis carried out by Harsh Rathore [28] discusses in brief about SFRC and the very sources of inception of fibre reinforced concrete. He also tells about each and every aspect related to FRC's focusing on SFRC mainly. His findings were; much of the application of HP-SFRC remains in the areas of long span bridges and high raise buildings, it is used more for bridges than buildings in Europe and Japan, while more buildings than bridges used in HPC in the U.S. However he suggests that the situation was changing and use of HPC was increasing in buildings these days. He concluded that much research continues to be focused on the mechanical properties of high-and very high strength concretes with or without fibres and their structural applications. Shear strengthening of reinforced concrete beams using glass fibre reinforced polymer strip by Rupesh V. and Sreegith. R [29] deals with the work of shear strengthening of shear deficient reinforced concrete beams using glass fibre reinforced polymer strips. They found that there was significant improvement in shear capacity when compared with control specimen. Glass fibre reinforced polymers inhibited the propagation of cracks and improved the shear capacity of the specimen. The experiment was carried out using u wrap and side wrap and U wrap was found to be more effective. There are various scope of the future work presented by the authors like using aramid fibre cloth and carbon fibre cloth, application of cyclic and reverse cyclic loading etc. Study on mechanical, flexure and shear behavior of recron steel fibre reinforced concrete was carried out experimentally by Revathi B. and Resmi V. Kumar [30] aims at the evaluation of the effect of two different types of fibres, namely steel and recron on the strength of concrete. The results from the study depicted the role of steel fibres and recron fibres in reducing macro and micro cracks, improving ductility, energy absorption capacity etc. It was also found that the workability decreased with increase in percentage of fibre addition. Number of cracks as well as the width of the crack was also found less in case of fibre reinforced beam. The compressive strength, splitting tensile strength and flexural strength increased up to 1.2% steel fibre addition and then decreased. The toughness also increased. Flexure and shear behavior of lathe scrap steel fibre reinforced concrete beams was studied by Bhavya A.K. and Resmi V. Kumar [31] with the objective of studying workability, compressive strength, split tensile strength, flexural strength and shear behavior of RC beam by incorporating scrap steel fibres in various percentages by weight of concrete. It was arrived at the conclusion that the workability decreased with the increase of the dosage of fibres. Compressive strength, splitting tensile strength and flexural strength increased up to 6% fibre addition and then decreased. It was also found that the addition of fibres improved the first crack load significantly the improvement was marginal for ultimate load in case if flexural failure. The scope presented by them talks about finding out crack patterns of beam column joint and durability properties of SSFRC. And they also felt that torsional behavior of beams and column joint can be studied. Seena Salim and Deepti R. Nath [32] oriented at studying the flexural behavior of hybrid fiber reinforced SCC ferro cement slabs produced with ternary blended cementitious materials. Later on they found that the split tensile strength of concrete due to the addition of steel fibre is more than that concrete with poly propylene fibre. It was also found that the flexural strength increased with an addition of steel fibres. Steel fibres were effective in in reducing the micro cracks and undergo ductile failure while polypropylene fibres were effective to reduce micro cracks and undergo brittle failure. Flexural strength of hybrid fibre reinforced ternary blended self compacting micro concrete after 28 days had strength nearly same for 100% steel fibre and equal proportions of fibres. The compressive strength of hybrid fibre reinforced ternary blended self compacting micro concrete for 0.25% of steel and 0.25% of polypropylene fibre by volume of cement was maximum compared to other proportions. Shear behavior of reinforced concrete beams incorporating metakaolin and steel fibres by Deepthi Dennison and Jean Molly Simon [33] mainly focused at studying the strength and structural behavior of reinforced concrete beams incorporating mineral additive such as metakaolin along with steel fibres of M20 grade. The metakaolin was added in different varying % such as 0%,5%, 7.5%,10% and 12% where as the crimped steel was added by 1.5%, 2%, and 2.5% by volume of concrete. The optimum replacement percentage of metakaolin was found to be at 10%. And the optimum dosage for the combined addition of metakaolin and crimped steel fibre was found to be at 10% and 1.5% respectively. The conclusion described was that as the percentage of MK increased the dosage of SP also increased because of the higher surface area of MK. After 10% replacement all the mechanical properties had a decreasing trend. The percentage increase in the first crack load for beams strengthened with 10% MK and 1.5% CSF in shear is 70% greater than that of corresponding control beams and it was because of the excellent tensile and bond strength of CSF. The ultimate shear strength of beams strengthened with 10% MK and 1.5% CSF is 32% greater than control beams. Experimental study on flexural and shear behavior of hybrid fibre reinforced self compacting rubberized concrete beam by Taksheem N. and Anu A. [34] partially replaced fine aggregate with the crumbed rubber from the waste tyre. Mechanical properties of rubberised SCC of M25 grade were studied. Specimens with 10% rubber content showed satisfactory flexural strength when compared with the control mix and thus it was selected as the optimum dose. It was also found that the inclusion of hybrid fibre with the increase in percentage of polypropylene reduced the fresh properties of SCC but was in the EFNARC limit. Reduction in compressive strength was found due to the addition of the crumb rubber however it was improved with the addition of fibres. The scope of the work as explained by the authors are work could be extended by varying different parameters like aspect ratio of fibres and different combinations of steel and other type of fibres. They also mentioned that the studies could be made with the higher grade of concrete. Modeling with finite element analysis could also be done. Self compacting rubberised concrete (SCRC) was developed using scrap tyres by Jeena R.B. and Deepthi R.N. [35] and to improve the engineering properties steel and polypropylene fibres were added for a total volume fraction of 0.5%. It was aimed to find out the load deflection behavior, ductility, compressive strength and energy absorption capacity. The result drawn showed that there was decreased compressive strength than the normal SCC but its use can be justified for solving a big ecological problem with proper management and utilization of waste tyre rubber. A rubber replacement of 10% by volume of fine aggregate can be considered as optimum dosage as it is nearly equal to the target strength of concrete. It was also concluded that the reduction in the compressive strength by the use of the scrap tyres can be overcome by using steel fibres.

III. EXPERIMENTAL STUDIES ON DURABILITY PROPERTIES

Durability of concrete can be defined as ability to resist weathering action, chemical attack, abrasion, or any process of deterioration.

Two levels of study firstly a static measurements and second level connecting with the high cycle fatigue – Wohler curves was carried to study the fatigue and fracture parameters of various glass fibre cement based composites [16]. The outstanding conclusion drawn was that the key to the success of improving the fatigue life of concrete with the addition of fibres seemed to be related with the distribution of the fibres in concrete. On top of that it was also observed that if the fibres were not well dispersed in concrete, the addition of fibres may have a detrimental effect on the fatigue life of fibre based composites. Salih Taner Yildirim and Cevdet [27] investigated the effects on freeze-thaw durability of fibres in concrete and suggested that it was important that glass fibres should not be used in the places exposed to freeze-thaw cycles and steel fibres which have different levels of brittleness, those with smaller dimensions in particular, should be investigated for the effects of freeze-thaw cycles.

IV. EXPERIMENTAL STUDIES ON STRENGTH AND DURABILITY PROPERITES

Laboratory analysis carried out on the combined effect of steel and glass fibre on compressive strength and flexural strength as well as on the durability by Puttavva and Dr. V Ramesh [3] targeted in improving the tensile property of concrete using steel and glass fibres at varying percentage. 0.5% and 0.25%, 0.525% and 0.3% and 0.55% and 0.35% of steel and glass fibres were used by volume of concrete. The conclusion was that the concrete having a mix of 0.525% and 0.3% of steel and glass fibre gave the maximum strength. Also that the compressive strength of concrete exposed to acid was found to be less. Jan Toman and Robert Cerny [12] analyzed the role of exact knowledge of mechanical, hygric and thermal parameters of fiber reinforced concrete containing the glass fiber and carbon fibers. Experimental study on the behavior of glass fibre reinforced concrete by A. Reynold Thomas and S. Raguraman [21] studied the hardened properties such as compressive strength, split tensile strength, initial surface absorption. The analysis of the experiment showed that addition of the GF increases the compressive, split tensile and flexural strength. It was observed that the addition of GF the bleeding reduced as well as workability also decreased. Addition of 0.2% by weight of cement of glass fibres shows maximum increase in compressive strength and flexural strength by 18% to 20%, and 15% to 20% respectively with respect to PC mix without fibres in 28 days of curing. The research described by paper of Sung Woo Lee, Sokhwan Choi, Byung-Suk Kim, Young-Jin Kim, Sung-Yong Park [22] deals with the study with the behavior of concrete filled composited tubes which are often used as marine piles. Numerical procedure to construct P-M diagrams for composite piles was also developed and the results were compared with experiments. Behavior of mixed fibre reinforced concrete exposed to acids [23] was experimented by Urooj Masood, Dr. B. L. P. Swami and Dr. A. K. Asthana. They worked in finding out the durability criteria of mixed fibre reinforced concrete to acids and salt resistance. Comparison of texture, denseness of the exposed and unexposed specimens are done by studying the properties like pH, conductivity and weight loss at 30 days, 60 days, 90 days,120 days and 180 days. Compressive strength was studied after 180 days of exposure. It was concluded by them that the proportion of 25 % and 75% steel fibre exhibited higher resistance to sulphuric acid. Experimental investigation was carried on the strength and durability properties of hybrid fibre reinforced concrete [24] by Sudheer Jirobe, Brijbhusan S., Maneeth P D using crimped steel fibre and polypropylene fibre with different proportions to find the strength and durability properties. Durability properties such as sorptivity and strength properties like tensile, flexural and impact strength of concrete of M25 grade was studied. It was concluded that hybrid ratio of 1.5% i.e. 0.75% of steel and polypropylene each gives the maximum results in all strength parameters. Sorptivity is more as the percentage of fibres addition is more and at 0.5% the hybrid fibres gives the same sorptivity value as compared to the conventional concrete. Glass fibre are highly resistance to fire, thus a laboratory experimental investigation [6] on the strength as well as the fire resistance properties of the FRC was conducted and the results were compared with the properties of the conventional concrete. With the addition of 0.5% fibre increases the compressive strength by 13%, flexural strength by 42% and split tensile strength by 20%. Fire resistance test results shows that there is the reduction of compressive strength, after heating the concrete at 300C for 2 hours. With the addition of 0.5% and 1% of glass fibre shows the decrease in the compressive strength to be 32% and 25% respectively, where as for the conventional concrete the value reaches to 32%. Experiments were carried out to study the strength, durability and behavior of beams using S.C.C. with E- glass fibre strands [18] with the partial replacement of cement by fly ash. In their experiment they found that even the addition of small amount of glass fibre i.e. 0.03% and 0.06% showed a notable increment in the properties like compressive and tensile strength, durability and load carrying capacity. They concluded that 0.06% addition gave better results compared to the 0.03% and thus had a future plan of conducting the experiment using 0.09% of glass fibre.

V. SUMMARY AND CONCLUSIONS

The current review paper reveals the studies carried out on fibres reinforced concrete. The paper mainly focuses on strength, durability properties of concrete by addition of various fibres with different dosages. The optimality and effect of fibres on concrete properties are studied and behavior of concrete is experimentally verified by casting cubes, cylinders and beam specimen.

Studies have shown that the addition of steel fibres in a concrete matrix in proves all the mechanical properties of concrete, especially tensile strength, impact length and toughness. The resulting material possesses higher compressive, tensile strength and better ductility.

From the literature papers referred on various fibres, its properties, significance, effect, impact on strength and durability properties are focused and brought into picture for the study and future research. Following conclusions could be drawn from present papers.

1. The Mechanical properties such as compressive strength, tensile strength, toughness, impact, flexural etc are greatly influenced by addition of fibres, optimum dosage of fibres governs these properties and must carry out optimality study on various fibres.
2. The Type of fibres, selection of fibres, properties like length, diameter aspect ratio, its effect on properties of concrete changes with addition of dosage. The prime importance must be given for selection of fibre, its type etc.
3. The Various fibre used in concrete significantly improves many properties of concrete. The combination of fibres thus shows advanced improvement and great changes in properties of concrete.
4. The Addition of fibres with additional supplementary cementations material such as fly ash, silica fumes etc should better performance by improving workability of concrete and inherent properties of concrete.
5. The Addition of fibres is carried out for special category such as self compacting concrete, high performance concrete, high strength concrete etc.

VI. SCOPE FOR FUTURE WORK

1. The Standard codal provisions may be made for mix design of fibre reinforced concrete, which would give the optimum dosage of various fibres for different grades of concrete.
2. The Interaction curves may be developed for different grades of concrete, strength and dosages of fibres. This would help the designer to evaluate the strength and dosages of fibres without carrying out detailed experimental study.
3. The Researchers may carry out detail study on various fibers and find out the optimum fibre, which helps in improving tensile property of concrete and behave as crack arrester.
4. The Fibres (natural and artificial) available must help in large quantities in construction of deep beams, foundations, slab etc. Thus should help in making the structure earthquake resistant.
5. The Work can be carried out on waste materials, which can be recycled and made in form of fibres and can be replaced in concrete, which would in turn help in the waste management of the world.

REFERENCES

[1] Ragi S. "*A comparative and experimental study on the mechanical properties of various steel and glass fibre reinforced high strength concrete*" International research journal of engineering and technology (IRJET) Volume: 02 Issue 04 (2015) pp 129-133.

[2] Kene S. K., Vairagade S. V. and Sathawane S. "*Experimental study on behavior of steel and glass fibre reinforced concrete composites*" Bonfing international journal of industrial and management science Vol. 2, No. 4 (2012) pp 125-130

[3] Pammar R. P. and Ramesh V. "Experimental *study on combined effect of steel and glass fibres on compressive strength, flexural strength and durability of concrete and comparison with conventional concrete*" International journal of civil and structural engineering research Vol. 3, Issue 1,(2015) pp: 146-150

[4] Praveen K. G. E and Praveen K.S. "*Experimental comparative study on the mechanical properties of hooked end steel, crimped steel and glass fibre reinforced concrete*" International journal of Engineering Trends and Technology (IJERT) vol. 21, Num. 5 (2015) pp 252-256

[5] Chawla K. a d Tekwani B. "*Studies of glass fibre reinforced concrete composites*" International Journal of Structural and Civil Engineering Research vol. 2, No. 3(2013) pp 176-182

[6] Ravikumar S.C. and Thandacamoorthy T.S. "*Glass fibre concrete: Investigation on Strength and Fire Resistant properties*" ISOR Journal of Mechanical and Civil Engineering (IOSR-JMCE) Vol. 9, Issue 3 (2013) pp 21-25

[7] Harle S. and Tantarpale N. "*Steel Fibre Reinforced Concrete and Its Properties*" International Journal of Engineering Sciences and Research Technology (2014) pp 30-32

[8] Musmar M. "*Tensile Strength of Steel Fibre Reinforced Concrete*" Contemporary Engineering Sciences, Vol. 6 No. 5 (2013) pp 225-237

[9] Chandramauli K., Srinivasa R. T., Pannirselban N., Seshadri S. G. and Sarvana P. "*Strength Properties of glass fibre concrete*" Vol. 5, No. 4 (2010) pp 1-6

[10] Pradeepa "*An Experimental Study on Properties of Fibre Reinforced Self Consolidating Concrete*" National Conference on Research Advanced in Communication, Computation, Electrical science and structure (NCRACCESS) ISSN 2348-8352 (2015) pp: 38-41

[11] Khan F. and Ahmad J. "*To Study the Properties of Latex Modified Steel Fibre Reinforced Concrete*" International Journal of Recent Research in Civil and Mechanical Engineering (IJRRCME) Vol. 2, Issue 1(2015) pp: 261-267

[12] Toman J. and Cerny R. " *Properties of Glass and Carbon Fibre Reinforced Cement Composites for their Technical Application*" Grant agency of the Czech Republic, under grant number 103/00/0021 pp: 53-58

[13] Ramesh and Neeraja D. "*Experimental studies on Effect of different Fibre on the Behavior of Structural Component*" International Journal of Advanced Technology in Engineering and Science. Vol. 03, Special issue no. 01(2015) pp: 664-674

[14] Shrikant M. Harle" *A Review on the Performance of Glass Fibre Reinforced Concrete*" International Journal of Civil Engineering Research. Vol.5, No.3 (2014) pp: 281-284

[15] Harle S. and Meghe R "*Glass Fibre Reinforced Concrete and its Properties*" International Journal of Engineering and Computer Science" Vol. 2, Issue 12. (2013) pp: 3544-3547

[16] Seiti S. and Kersner Z. "*Fatigue and Fracture Parameters of Various Glass Fibre Cement Based Composites*" Support of project GA CR 103/08/0963 from the Czech Science foundation and project AV OZ 20410507 pp: 1-7

[17] Pastiwan N. and Pimpkar S.S "*Glass Fibre Reinforced Concrete Used in construction*" International Journal of Technology and Engineering System (IJTES) Vol. 2, No 2 (2011)

[18] Kumar R.K. and Mahendran N. "*Experimental Studies on Strength, Durability and Behavior of Beam using Self Compacting Concrete with E-Glass Fibre Strands*" International Journal of Engineering Research and Technology (IJERT) Vol. 2, Issue 4 (2013) pp:1026-1034

[19] Murali G. Santhi A. S. and Ganesh M. G. "*Effect of Crimped and Hooked End Steel Fibre on the Impact Resistance of Concrete*" Journal of Applied Science and Engineering. Vol. 17, No. 3 (2014) pp: 259-266

[20] Ameeri A.A. "*The Effect of Steel Fibre on some Mechanical Properties of Self Compacting Concrete*" American Journal of Civil Engineering 1(3): (2013) pp:102-110

[21] Thomas R. A. and Raguraman S. "*Experimental Study on the Behavior of Glass Fibre Reinforced Concrete*" Journal of Engineering Science Invention Research and Development. Vol. I Issue IX (2015) pp: 435-439

[22] Lee W. S., Choi S., Kim S.B., Kim J.Y. and Park Y.S. "*Structural Characteristics of Concrete-Filled Glass Fibre Reinforced Composite Piles*" Ministry of Maritime Affairs and Fishers of Korea pp: 1-11

[23] Masood U., Swami B.L.P. and Asthana A.K. "*Behaviour of Mixed Fibre Reinforced Concrete (MFRC) Exposed to Acids- An Experimental Study*" The Master builder Co.In [2012] pp: 118-126

[24] Jirobe S and Brijbhushan. S." *An Experimental Investigation on Strength and Durability Properties of Hybrid Fibres Reinforced Concrete*", Internationa;l Research Journal of Engineering and Technology(IRJET) Vol-02, Issue-05, (2015).PP No-891-896

[25] Vikrant S. Vairagade and Kavita S. K. "*Experimental Investigation on Hybrid Fibre Reinforced Concrete.* " International Journal of Engineering Research and Application (IJERA) Vol-2, Issue-3 (2012). PP NO, 1037-1041

[26] Vaishali G.G, "*An Experimental Investigation on Glass Fibre Reinforced High Performance Concrete with Silicafume as Admixture*", Use Glass Fibre in High Performance Concrete Best on the Present Experimental Investigation (2010).

[27] Yilrim S.T. 7 Ekinci C.E., *"Effects on Freeze-Thaw Durability of Fibres in Concrete*", www.intechopen.com.

[28] Rathore H," *Steel Fibre Reinforced Concrete: An analysis*", the Inquisitive Meridian Online ISSN-2347-6257.

[29] Rupesh V and Sreejith R, " *Shear Strength of Reinforced Concrete Beams using Glass Fibre Reinforced Strip*", International Journal of Research and Technology (IJERT), NCRACE-2015.

[30] Revathi. B and Mrs. Kumar R.V., " *An Experimental Study on Mechanical, Flexure and Shear Behavior of Recron-Steel Fibre Reinforced Concrete*", International

Journal of Engineering and Technology (IJERT), NCRACE-2015.
[31] A.K. Bhavya and Kumar Mrs. R V, "*Study on Flexural and Shear Behavior of lathe Scrap Steel Fibre Reinforced Concrete Beams*", International Journal of Engineering and Technology (IJERT), NCRACE-2015.
[32] Salim S and Nath D R. " *Flexural Behavior of Hybrid Fibre Reinforced Ternary Blended Self Compacting Mico-Concrete Ferrocement Slabs*", International Journal of Engineering and Technology (IJERT), NCRACE-2015.
[33] Dennison D and Simon J M, "*Shear Behavior of Reinforced Concrete Beams incorporating Metakolin and Steel Fibres*", International Journal of Engineering and Technology (IJERT), NCRACE-2015.
[34] Noohu T and A.A, "*An Experimental Study on Flexural and Shear Behavior of Hybrid Reinforced Compacting Rubberized Concrete Beam*", International Journal of Engineering and Technology (IJERT), NCRACE-2015.
[35] Babu J R and Nath D R, "*Mechanical Properties and Behavior of Hybrid Fibre Reinforced Self Compacting Rubberized Concrete Beam*" International Journal of Engineering and Technology (IJERT), NCRACE-2015

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