ISSN No:-2456 –2165

A Review on Shear Behaviour and Durability Aspect of Hybrid Fibre Reinforced Concrete

N.Suresh Kumar
Associate professor of civil Engineering, Kalasalingam Academy of Research and Education, Kalasalingam University
Tamilnadu-626126 ,India
civilsuresh69@gmail.com

Dr. C Ramesh Babu
Asc.Prof. & Head of Department of Civil Engineering, Kalasalingam Academy of Research and Education
Kalasalingam University
Tamilnadu-626126 ,India

Himanshu kumar , Vimaleshwar M. Manikandan,
B.Tech, Student of Civil Engineering , Kalasalingam Academy of Research and Education, Kalasalingam University Tamilnadu-626126 ,India
kumarhimanshu3210@gmail.com

Abstract—When two or more different types of fibres are added to concrete to make the composite structure and it gives maximum strength to concrete that type of concrete is known as hybrid fibre reinforced concrete (HFRC).In this paper we going study about the shear behavior and durability aspect of HFRC. Two or more fibre of different properties are mixed together and provides strength and stability to concrete structure . Hybrid Fiber reinforced concrete can be used in various field like bridge , structure in earthquake region, shotcrete, architectural panels, precast products, offshore structures, structures in seismic regions, thin and thick repairs, crash barriers, footings, hydraulic structures and many other applications.

Keywords—Cracking Pattern, Shear Properties, Durability, Steel Fibre Reinforcement, Propylene Fibre, Hybrid Fibre Reinforced Concrete

I. INTRODUCTION

In present days, Hybrid Fibre reinforced concrete is cement based composite material has been developed. Hybrid Fibres in concrete provide a medium of arresting crack growth and increase the strength, stiffness, durability and load carrying capacity.It is used in construction work successfully because of its high flexural tensile strength, resistance to splitting, impact resistance and high permeability factor and frost resistance. this is a successful method to increase the toughness, shock resistance, and stiffness of structure. Short discontinuous fibre have the advantage of being uniformly mixed and dispersed in concrete. Nowadays, the application of fibre in structure components has spread widely throughout the world especially for hybrid fibre. Furthermore, when mixing fibres in concrete, it needs to be done properly to avoid failure in the structure components. In order to produce better concrete and to overcome some weaknesses of single fibre in concrete, hybrid fibre is introduced in this study. Hybrid fibre are based on its fibre size, where one fibre may be small and it provides micro-crack control at initial stages of application of load and the other fibre may be larger which provides joint mechanism across cracks. Hybrid fibre are also based on the function and properties of fibre, where one type of fibre provides strength or toughness in the concrete structure , while the another provides durability ,load resistance. From the last few decade, there are a remarkable increase in the interest towards the use of HFRC. The hybrid fibres are an interesting material for construction industry. A large number of research work has been done on durability of hybrid fibers in concrete in recent years. The life span of concrete structure is normally upto 50 to 100 years. The fibres bridging the cracks contribute to increase the strength, the failure strain and the toughness of the composite. The various properties of hybrid fibre increase the durability of concrete structure and the life-span of concrete structure will increase. The shear stress acts parallel or tangential on section of a material. When a hybrid fibre reinforced concrete beam is subjected to bending load, the fibers above the neutral axis are in compression and the fibers located below the neutral axis are in tension. A hybrid concrete beam with longitudinal steel when subjected to external loads will develop diagonal tensile stresses, which will tend to produce cracks. The cracks are vertical at the centre and inclined on the other parts of the beam. The stress due to which the inclined cracks are formed in the beam is known as diagonal tension stresses.

II. LITERATURE REVIEW

For the purpose and to defend the research work, a number of research papers are analyzed. Following are the experts from the different research work performed by number of academicians and researchers.

A/c to Asc.Prof. Dr. Nasr Zenhom(Helwan University 2014):- From his study they found that by Adding of fibers to high strength concrete increases the first crack load and ultimate load. For 0.75% volume fiber the ultimate load increased by 48.2% at a/d=1.5, for 0.75% fiber the ultimate load increased by 44.5% at a/d=1.7. In addition, for 0.75% volume fiber the ultimate load increased by 39% at a/d=2.2. Adding of steel fibers to the concrete mix improves the shear strength of RC beams and tends to increase initial and

post cracking stiffness of beam. For each a/d ratio, increasing the volume fraction of steel fibers can increased the ultimate loads, the shear strength, and decreased ultimate deflections. The combination of stirrups and steel fibers demonstrates a positive hybrid effect on the mechanical behavior, and is one of the optimal choices for improving the shear capacity.

Test results show that plasticity, cracks propagations and load capacity of elements are greatly influenced by steel fiber volume added. Steel fibers work as splice, which help the matrix to exhibit less cracks, and increase the stiffness.

The shear span to depth a/d ratio has a strong influence on the shear strength of HSRC beams like NSRC beams.

The shear strength decreases with the increase of a/d values for the same longitudinal steel. The increase in shear span ratio increases the number of cracks formed and as result more cantilever force applied at the cracked concrete, reducing the shear strength of concrete to greater extent. In general, by change ratio of a/d from 1.5 to 2.2 the failure load decreased by 21 percent at the same fiber content 0, 0.25 percent, by comparing between the strength for span to depth ratio 1.5 and 2.2 it found that, the shear strength in a/d=1.5 is more than that in a/d=2.2 because of arch action performed on lower shear span ratio. From studying, the effect of span to depth ratio on the shear failure and using discrete steel fiber it was found that, by increasing span to depth ratio the efficiency of used discrete steel fiber decreased.

A/c to M.P. karthik(KSCE Journal of Civil Engineering,(2015)Korean Society of Civil Engineers)-The test result first indicated that at low fibre volume fraction, it is possible to obtain material with enhanced strength and improved toughness from hybrid fibres.The better workability of fresh concrete was obtained in the combination of Steel and PP. The best composite properties were obtained from the hybrid containing polypropylene and steel fibres, which had the greatest strength. The interaction between the Steel and the PET fibres is lower than the Steel and PP fibres, because of observing the water and the balling effects were made the quality of concrete as poor. The addition of steel fibres is the mainly working as the strength material, the PP and PET fibres were working as the crack resistor. The experimental results show that increasing the side concrete cover to stirrup leads to wider diagonal crack spacing and partial absence of shear crack opening control at the surface of the elements. Diagonal cracking is mainly noted the main reason causing the difference in crack opening displacements at the same stirrup strain.

A/c to A. Meda(www.rilem.net 23 September 2004) In this paper, the experimental results of shear tests on beams are presented. The experimental results show that the beams reinforced only with steel fibres show a similar, or even better, post cracking behaviour than the beams with the minimum amount of transverse reinforcement. results from six tests confirm this important result. In prefabrication, this is particularly appealing for facilitating the industrialization of the production and introducing an improvement in the overall characteristics and durability of the products. When fibres are used in addition to conventional transverse reinforcement the shear strength significantly increases. Steel fibres also reduce the width of shear cracks, thus improving also durability.

A/c to A.L.Ardeshana(www.ijera.com, July-August 2012)**:-** The author found from his study that addition of hybrid fibers increase durability of concrete structure .The compressive strength of concrete increases with increase in amount fiber dosage up to 0.3%, then it starts decreasing. Higher durability provides the higher resistance to marine structures attacks. The polypropylene fibers bridge the cracks and minimize interconnecting voids. This concrete will be used for water retaining structures like water tanks, swimming pools.

A/c to Juli Asni Lamide:-it can be concluded that, steel fibres plays the role as a particular substitution of conventional shear reinforcement bars where the addition of steel fibres can significantly increase the shear strength and ductility of reinforced concrete members. At the same time, steel fibres are able to delay the propagation of cracks due to the internal bridging effect in reinforced concrete beams.

***A/c to Noor Azlina Abdul Hamid* :-**Based on the test results presented in this paper, Beams with lesser a/d ratios shows higher ultimate capacity compared to beam with greater a/d ratios. Shear capacity of GFRP RC beams is lower compared to steel RC beams. The use of GFRP bars as longitudinal reinforcement bars affect the shear performance and patterns of cracking. High amount of GFRP bars increased the ultimate capacity and deflection of the beams. Closes diagonal cracks significantly developed in GFRP RC beams. Higher strain values were recorded on stirrups in beam reinforced with GFRP bars rather than stirrups in steel RC beams.

A/c to G. Somma (The 14th World Conference on Earthquake Engineering October 2008, Beijing, China):-In this paper the author is collected the large number of interior and exterior FRC joints tested by others under seismic load condition and had concluded that the effective application of steel fibers in the joint concrete mix results in significantly improved joint behavior under seismic loading, in particular with an increased shear resistance.In the paper the author derived a new expression for predicting the shear strength of FRC joints. It takes into account the contribution of the fibers together with the transverse reinforcement one. This expression has been compared with the outcomes from the experiments on 37 FRC joints subjected to earthquake loading, and with others expressions provided by Codes and authors.

A/c to Ahmad Saudi Abdul-Zaher(Journal of Engineering Sciences Assiut University Faculty of Engineering ,March 2016):- The research has been presented in this paper with a view to understand the role of fibers on the shear strength of concrete. The shear crack formation load and the ultimate load increase with increase in the percentage of fibers, because the fibers increase the tensile strength of concrete. The presence of 0.2% and 0.6 % steel fibers resulted in 12.5 % and 31.25% increase for the values of the first shear cracking load, respectively. However, they led to 11.43% and 28.57% increase for the values of the ultimate load,

respectively. The presence of 0.2% and 0.6% glass fibers led to the increase of the percentage of the value of the first shear cracking load to 5.88% and 18.75%, respectively. As well as, led to 2.86% and 22.86% increase for the values of the ultimate load, respectively. The addition of fibers not only improved the ultimate load capacity of the tested specimens,but also increased the stiffness and hence reduced the deflection at the same load. This improvement is more pronounced in case of beams reinforced with fibers and stirrups.The values of the maximum deflection increase with the increase of percentage of fibers. This is primarily because concrete becomes more ductile and hence it fails after deformation. The presence of stirrups in the shear zone minimizes the dangerous of the sudden and brittle type of the shear failure. Also, the presence of fiber and stirrups led to increase the value of ductility due to the fact that fibers increase the tensile strength of concrete.

A/c to Ahsana Fathima K M(International Journal of Research in Engineering & Technology):-The steel fibre reinforced concrete yield higher compressive strength with addition of 0.75% steel fibre by volume of concrete. Fibre reinforced concrete with crimped steel fibre of 25mm length with aspect ratio 50 yields better compressive strength than hooked end steel fibre of 30mm length with aspect ratio 50. The steel fibre reinforced concrete yield higher splitting tensile strength with addition of 0.75% steel fibre by volume of concrete. The polypropylene fibre reinforced concrete yield higher splitting tensile strength with addition of 0.5% polypropylene fibre by volume of concrete. Fibre reinforced concrete with crimped steel fibre of 25mm length with aspect ratio 50 yields better splitting tensile fibre reinforced concrete yield higher flexural strength with addition of 0.75% steel fibre by volume of concrete. The polypropylene fibre reinforced concrete yield higher flexural strength with addition of 0.5% polypropylene fibre by volume of concrete. Fibre reinforced concrete with crimped steel fibre of 25mm length with aspect ratio 50 yields better flexural strength than hooked end steel fibre of 30mm length with aspect ratio 50.

A/c to Sudheer Jirobe(International Research Journal of Engineering and Technology (IRJET) Aug-2015):- from this study they found that there is improvement in Compressive strength of HFRC compare to conventional concrete because of addition of fibers. The maximum increase in compressive strength observed at having hybrid ratio 1.5 % i.e. 0.75 % steel fiber and 0.75 % polypropylene fiber and When compared with controlled concrete the increase in the compressive strength with fiber addition in percentages of 0.5%, 1%, 1.5% is 10.75%, 27.26%, 33.79% respectively.

Impact strength of HFRC increases as the percentage of fibers increases the no of blows required to failure the specimen also increases. Thus impact strength increases with the increase of addition of fibers in the mix. this shows the HFRC increase the durability of concrete structure .

A/c to Mrs. M. M. Magdum(International Journal Of Engineering Sciences & Research Technology, july 2017):-In this paper the author find the following conclusion .The material which has less water absorption which shows high strength means that is more durable.

In Compressive Strength result shows HFRC + alccofine give exceptionally high compressive strength as compare to plain concrete.

In water adsorption test addition of HFRC + alccofine gives lower water absorption while addition of only fiber increases the percentage.

A/c to Wilson Nguyen(Fourth International Conference on Sustainable Construction Materials and Technologies, USA, August 2016):- The authors performed a series of experiments to investigate the long term durability enhancement of hybrid fiber reinforced concrete compared to conventional concrete. Use of hybrid fibre reinforced concrete sample was found in all experiments to reduce corrosion activity and related damage by providing mechanical control of cracks. Such control is proposed as an effective method to increase the service life of structural composites, making these structures more sustainable by having greater longevity and not requiring extensive rehabilitation while in service.The flexural and splitting crack resistance provided by hybrid fiber reinforcement is beneficial for reinforced concrete structures subjected to crack-inducing service loads. Splitting cracks were found to be most detrimental to reducing time to corrosion initiation.Because hybrid fiber reinforcement suppressed splitting crack formation, as well as minimized flexural crack openings, HyFRC specimens loaded to 54 kN behaved in a passive state up to 52 weeks, while plain concrete specimens at the same load level reached active corrosion after 12 weeks .

A/ c to (Mu et al. 2002; Poon et al. 2006):-Corrosion-induced cracks also accelerate the ingress of detrimental ions, resulting in further cracking. The introduction of fibres into concrete has been considered effective in reducing cracking and enhancing durability in cement-based composites.

A/C To M. Nohitha(international journal of advanced technology and innovative research,.07,July-2016,):-There is improvement in Compressive strength of HFRC compare to conventional concrete because of addition of fibers. The maximum increase in compressive strength observed at having hybrid ratio 1.5 % i.e. 0.75 % steel fiber and 0.75 % polypropylene fiber and When compared with controlled concrete the increase in the compressive strength with fiber addition in percentages of 0.5%, 1%, 1.5% is 10.75%, 27.26%, 33.79% respectively.Impact strength of HFRC increases as the percentage of fibers increases the no of blows required to failure the specimen also increases. Thus impact strength increases with the increase of addition of fibers in the mix. When compared with controlled concrete the increase in the impact strength with fiber addition in percentages of 0.5%, 1%, 1.5% respectively.

A/c to S.G. Millard(International Journal of Impact Engineering, Elsevier, 2010):- In this paper the author described the Increasing the level of steel fibre content also resulted in an increase in the maximum shear strength under quasi static loading . Shear failure resulted from a sliding

friction action along the shear plane and pullout of the fibres in all cases.

It was found from studies of the shear behaviour that at high shear stress loading rates of up to 120 MPa/s, no significant dynamic increase factor was observed. Shear is expected to be the dominant mode of behaviour of UHPFRC(Ultra high performance fibre reinforced concrete) under blast loading at close standoff. Hence no strain rate enhancement is recommended when designing a blast resistant UHPFRC for shear punching resistance.

***A/c to Jin-Ha Hwang*(** October 2013,*Materials* 2013):-Most of shear strength equations for SFRC members are relatively simple, but provide a low accuracy, as they have been derived empirically based on experimental test results. Some analytical models can estimate shear behavior and strength of SFRC members, but cannot provide the contribution of steel fibers to the shear strength and cannot demonstrate the pullout failure of steel fibers. In this study, the softened truss models were modified appropriately for SFRC members, in which the steel fibers were modeled as independent tensile elements so that the proposed models can reflect the details of steel fibers such as the effects of the shape, length, and volume fraction of steel fibers. The proposed models were also compared to the test results of 85 specimens collected from literature. From this study, the following conclusions were drawn.The softened truss models were modified to be suitable for the analysis of SFRC members by modeling steel fibers as independent tensile elements, which, in particular, can estimate the stresses of steel fibers according to the detailed characteristics of the steel fibers. The contribution ratios of steel fibers on the shear strength of SFRC members were calculated by the proposed models, which was found to be approximately 30% at the 1%–1.5% steel fiber volume fraction. Based on the observations of the shear contribution ratio of steel fibers, the optimal range of the steel fiber volume fraction, in terms of shear performance, is 1%–1.5%.

A/c to Manisha M(6th International Conference on Recent Development in Engineering Science Humanities Management,May 2017):-From the review of research articles mentioned in this paper, the HFRC is an innovative engineering material. Both the tensile and compressive strength of hybrid fiber reinforced concrete decreases with increasing temperature. The workability/ rheological properties of concrete mixtures are found to depend on types, dosages, geometry of fiber, and in cases of hybrid mixtures, interaction and synergic properties between different fiber types also play a critical role. The enhancements in modulus of rupture, deflection capacity and energy absorption capacity were different according to the types of macro fiber as the amount of micro fiber blended increased. High performance hybrid fiber concrete should first possess good capacity on compaction and static properties, such as compressive strength, MOR, and splitting strength. The main reasons for adding steel fibers to concrete matrix is to improve the post-cracking response of the concrete i,e.to improve its energy absorption capacity and apparent ductility, and to provide crack resistance and crack control.Use of hybrid fibers in specimens increases significantly the toughness indices and thus the use of hybrid fibers combinations in reinforced concrete would enhance their flexural toughness and rigidity and enhance their overall performances.

III. ACKNOWLEDGMENT

The review study describe in this paper is a part of my B-Tech , Final year project work at Department of civil engineering, kalasalingam university, Tamilnadu-626126 , India.

REFERENCES

[1]. G.Suguna,Mrs.S.Parthiban,(Experimental And Investigation of Hybrid Fiber Reinforced Concrete),International Journal of Scientific & Engineering Research, Volume 7, Issue 4, April-2016.
[2]. Behavioural Study Of Steel Fiber And Polypropylene Fiber Reinforced Concrete International Journal Of Research In Engineering & Technology ,Vol. 2, Issue 10, Oct 2014,
[3]. M. P. Karthik and D.Maruthachalam (Experimental Study on Shear Behaviour of Hybrid Fibre Reinforced Concrete Beams), KSCE Journal of Civil Engineering (2015), Korean Society of Civil Engineers.
[4]. A.Meda,F.Minelli,G.A.Plizzariand,P.Riva, (Shear behaviour of steel fibre reinforced concrete beams), Italy,www.rilem.net,Materials and Structures 38 (April 2005)
[5]. Juli Asni Lamide, Roslli Noor Mohamed, Ahmad Baharuddin Abd Rahman, (Experimental Results On The Shear Behaviour Of Steel Fibre Self-compacting Concrete Beams), Department Of Structure And Material, Faculty Of Civil Engineering,Universiti Teknologi Malaysia,Utm Johor Bahru, Malaysia.
[6]. K.Ramadevi, D. L. Venkatesh Babu, (Behaviour of Hybrid Fibre-Reinforced Concrete Frames with Infills Against Lateral Reversed Loads), July 2014 King Fahd University of Petroleum and Minerals 2014.
[7]. NoorAzlina,AzmiIbrahim,RendyThamrinandHanizah, AbdulHamid.(Investigation on the Shear Behaviour of Concrete Beams Reinforced with GFRP Reinforcement Bars),Faculty of Civil and Environmental Engineering, Universiti Tun Hussein Onn Malaysia, Johor,Malaysia,2Faculty of Civil Engineering, Universiti Teknologi Mara, Shah Alam, Selangor, Malaysia Faculty of Engineering, Universitas Andalas, Padang, Indonesia
[8]. H. Nikopour & M. Nehdi , (Shear Repair Of Rc Beams Using Epoxy Injection And Hybrid External Frp), The University Of Western Ontario, London,Materials And Structures (2011).
[9]. Yining ding Fasheng zhang, Torgal Fernando and Yulin zhang, (Shear behaviour of steel fibre reinforced self consolidating concrete beams based on the modified compression field theory), State Key Laboratory of Coastal and Offshore Engineering,Dalian University of Technology, China, Guimarães, Portugal Centre of Mathematics, University of Minho, Portugal

[10]. Manisha M. Magdum, Dr. V. V. Karjinni, (Hybrid Fiber Reinforced Concrete: A Review), 6th International Conference On Recent Development In Engineering Science Humanities Management, 14th May 2017 .
[11]. Er.Shahzaeb Azam Chowdhary,Er. Kshipra Kapoor,(A Review on durability and mechanical properties of steel and polypropylene fibre hybrid fibre reinforced concrete), Oct -2017 www.irjet.net
[12]. M. NOHITHA,V. MOUNIKA (Experimental Study of Strength and Durability Properties of Hybrid Fiber Reinforced Concrete for M25 Grade),July-2016,
[13]. Wilson Nguyen1a, Rotana Hay1b,Gabriel Jen1c and Claudia P.Ostertag (Long-Term Infrastructure Durability Enhancement of Hybrid Fiber-Reinforced Concrete Under Corrosive Environments) SCMT4,Las Vegas, USA, August 7-11, 2016.
[14]. Ningaraj C. Birajdar , Mrs. M. M. Magdum, (Durability of hybrid fibre reinforced concrete), IJESRT,July, 2017.
[15]. Sudheerjirobe,Brijbhusan.S,Maneeth.P. (Experimental Investigation On Strength And Durability Properties Of Hybrid Fiber Reinforced Concrete), (IRJET) ,Aug-2015.
[16]. .A.L.Ardeshana , Dr Atul K Desai, (Durability Of Fiber Reinforced Concrete Of Marine Structures),International Journal of Engineering Research and Applications (IJERA), August 2012.
[17]. .Hmad Saudi Abdul-zaher, Laila Mahmoud Abdul-hafez,Yasser Rifat Tawfic, Osama Hammed (Shear Behavior Of Fiber Reinforced Concrete Beams),Journal Of Engineering Sciences, March 2016.
[18]. .Properties of Polypropylene Fiber Reinforced Concrete and Structural Behaviour of Beam,Mr.Ashish Kumar Yadav1, Dr.Brajkishor Prasad, Dr.Virendra Kumar3and Meenu Mohan , International Journal of Innovative Research in Science,Engineering and Technology Website: www.ijirset.com,Vol. 6, Issue 6, June 2017.
[19]. G.Somma, (Shear Strength Of Fiber Reinforced Concrete Beam-column Joints Under Seismic Loading), The 14th World Conference On Earthquake Engineering, October 2008, China.
[20]. Dr.K.Vidhya, Dr.T.Palanisamy, R.Thamarai Selvan, (An Experimental Study On Behaviour Of Steel Fibre Reinforced Concrete Beams), International Journal Of Advanced Research Methodology In Engineering Technology,March 2017.
[21]. Jose Miquel Albaine, (Shear Strength Of Reinforced Concrete Beams Per Aci318-02 Pdh Course S153), 2002