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Steel Fibre Reinforced Light weight Aggregate Concrete

Ravpreet Kaur, Harvinder Singh

Abstract: ***Paper From the past studies on Steel fibre reinforced concrete, it has been established that the performance of concrete can be enhanced by incorporating fibres from waste materials from the commercial benefit and environmental aspect.. Reinforcing concrete with steel fibres (SFRC) increases the tensile strength of concrete thereby improving its brittle behaviour.The major applications of SFRC being in tunnel lining,underground structures,flooring. The analysis presented states that the light weight concrete when incorporated with the waste steel from reinforcement and formworks with different fibre contents yield the comparable outcomes as the already studied fibre reinforced concrete***

Keywords : Steel Fiber Reinforced Concrete (SFRC),Tensile strength,mechanical,Light weight concrete,LWAC,Steel fibres

I. INTRODUCTION

The most extensively used material for building and construction on earth is Concrete.A variety of concrete has been developed and is being used depending upon its suitability (strength and weight) for the construction of different types of structures. Since the improvement in the behavior of concrete (say its environmental affects, toughness, longevity) in both fresh and hardened states are the basis for analysis. To enhance the properties of concrete, fibres are added to the mixture during manufacturing. The use of fibres to reinforce a brittle material has been as long as 5000 years ago. From the past 5 decades, there has been rapid increase in the studies and applications of fibre reinforced concrete (FRC). The distinguished response of FRC has been in increasing the flexural capacity, durability, crack control. Also, it has been published that fibre reinforced concrete has improved compressive strength, significantly increased tensile strength and fatigue strength. Different types of fibres are available such as metallic, mineral and organic of which metallic are further of carbon steel and stainless steel, likewise mineral are asbestos and glass fibres and organic are natural and manmade fibres. Natural fibres are further classified as of vegetable and animal origin where vegetable origin are wood, leaf fibres and animal origin are as wool and hair fibres, silk and other filaments made fibres are of further two types i.e. synthetic and natural polymer. From all these different types of fibres, the most routinely used are the steel fibres because of its increased flexural rigidity, improved toughness, ductility leading to decrease in cracking, in addition to it also it can be molded to different shapes which all the more increases its scope of suitability for various structural applications.

Plain Concrete possesses a brittle behavior as glass i.e. it breaks/cracks easily because of its low tensile strength. When cracks appear on its surface, they make it more likely to be prone to detrimental agents causing premature saturation, scaling, corrosion. The studies on SFRC in the past have reported that FRCs have good crack resistance property such that that cracks cut back if at initial stage. FRCs exhibit higher strength and durability as compared to normal concrete, as the fibres incorporated restricts the growth of cracks hence acting as crack arrestors. The shape of fibre, its aspect ratio and percentage volume of fibres in concrete i.e. volume fraction affects the property of FRC. FRCs are differentiated on the basis of volume fraction of fibre such that low fibre (<1%), average (>1%- <2%) and as high (>2%). Experimental results published so far has reported that steel fibres in a volume fraction of 1-1.5% of concrete shows an increase in tensile strength, flexural capacity and compressive strength upto 100%,150-200% and upto 25% respectively. The fibre pattern resembles the pattern of distribution of stress in the concrete which explains its suitable imposition of the high strength concrete matrix. The results published by performing experimental research suggests that by adding steel fibres to the concrete does have shortcomings in rega rd to the decrease in workability and also the combining of fibres into the mix is all the more tedious and time consuming as compared to the traditional concrete mix.

The structures made of concrete are heavy with respect to the load it is designed to bear. As the infrastructure is developing ,particularly, the construction of tall structures, substantial in size and longer in length, the structures made of light-weight aggregate concrete (LWAC) with a variety of aggregates much lesser in weight, defined as light weight aggregates(LWA) have been widely researched upon and with the achievement gained have been put to use in recently.

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* Correspondence Author
Ravpreet Kaur*, [1]Research Scholar, Department of Civil Engineering, I.K. Gujral Punjab Technical University,Kapurthala,Jalandhar, Punjab,India.Email:preetwalia07@gmail.com
Assistant Professor, Department of Civil Engineering, SGT University, Gurugram,H aryana, India. Email: ravpreet_fet@sgtuniversity.org
Harvinder Singh, Department of Civil Engineering, Guru Nanak Dev Engineering College, Ludhiana,Punjab,India.Email:hvs1221@gmail.com.

This LWAC with its applications in the construction of structures has benefitted the construction industry as to capacity of bearing the tensile strain, superior insulating ability (heat and sound),,reduction in the value of thermal expansion coefficient and increased strength.

This LWAC has still not been widely accepted or used routinely because of the gaps in the material properties and for some reason the experimental testing has revealed as published in the studies that LWAC shows a higher brittle characteristic as compared with the normal concrete. For the same proportion of mix. With the advances in the study of LWAC, there has been a recent development of high strength light-weight aggregate concrete (HSLWAC) made up of variety of light weight aggregates exhibiting the strength in compression in the range of 50MPa-100MPa and much improved mechanical behavior as compared to the contemporary light weight aggregate concrete. With the increase in the strength of concrete compressive strength As the strength of concrete in LWAC increases, it exhibits more brittle behavior particularly in compression zone and tension zone. To resolute this brittle behavior and further enhancing the mechanical properties, LWAC is to be incorporated or reinforced with the fibres like glass,steel,carbon,plastic,mixed etc. From the investigations in the recent past, it has been concluded that the study on fibre strengthened light weight aggregate concrete, incorporates steel fibres only or has been combined with fibres nonmetallic in nature. The purpose of this study is that it demonstrates the influence on properties of LWAC by incorporating fibres in initial and final states.

Since to enhance the characteristics of LWAC,it has to be mixed with fibres and scrap. Fibre in particular to be added is steel fibre due to his specific gravity being high, resulting in increasing the density of the material. But the study has also suggested that if the volume fraction of steel fibre to be added is less than one, then there would be less or no significant improvement in the behavior of LWAC.

LITERATURE REVIEW

Hama (2017) established that plastic fibres can largely improve the flexural response of LWAC but the same is not true for the compressive strength. For this it was further suggested that in addition to plastic fibre if glass powder is introduced replacing the cement content in varied percentages will yield higher compressive strength.[1]

Rico et al(2017) presented that the reinforcing the lightweight aggregate concrete with fibres improves the ductile behavior of concrete both contemporary and conventional and hence the brittle behavior is dropped and hence tensile strength increases substantially.[2]

Zhao et al(2016) conducted the test to investigate the shrinkage(autogenous and drying) in steel fibre reinforced LWAC with the impact of applying the variation in the type of aggregates i.e. coarse and fine and differing both the water binder ratio and the percentage of steel fibres with respect to the volume of concrete. The results of the test conducted experimentally suggested that the shrinkage happened at a faster pace in first 28 days and then attained a near constant rate after about 90 days. [3]

Dahake & Charkha(2016) studied how the type of steel fibre influence the concrete strength when added to it. In the experimental work, the percentage of fibre content was fixed to 2.5%of the weight of cement. Compressive and flexural strengths were considered for research and the outcomes of SFRC as compared to primarily used concrete indicate that there is positive influence on the above mentioned strengths with using a variety of steel fibres at a given volume percentage of fibre content.[4]

Kamran et.al.(2015) performed experimental study on light weight concrete by adding steel wires from scrap and found that the addition of the scrap and steel fibres upto a 0.5% volume of light weight yields higher compressive strength. However if the steel wires and fibres are added in the volume fraction >0.5%of concrete will lower the compressive strength of the light weight steel fibre reinforced concrete member.[5]

Zinkaah (2014) proposed that to develop a steel fibre reinforced light weight concrete, crushed bricks be used as coarse aggregates to improve the compressive strength wherein the steel fibre volume content be 0.75% of concrete. It was also reported that increasing the fibre volume percentage from 0.75%-1% will show a decrease in compression from (43%) to (27%) in a week and upto 51% from 30% in 28 days.[6]

Rao et.al.(2013) investigated the mechanical properties of concrete with pumice used as aggregate and reinforced with steel fibres. Traditionally used aggregates were replaced by pumice in varied ratios from 25%to 100% by volume and steel fibre ratio varied from0.5% to 1.5% by volume. From this experimental procedure, it was observed that the higher values of pumice aggregates adversely effected the mechanical properties and unit weight of concrete. With the increase in fibre content and pumice content, the modulus of elasticity and capacity to deform decreased, while increasing the steel fibre content enhanced the split tensile strength, strength in compression, unit weight and flexural response.[7]

Mahmoud and Mehmud (2012) suggested that the increased brittle behavior and decreased mechanical properties as compared to standard concrete has led to lack of acceptance in industry. The addition of steel fibres into mix serves as a solution to above difficulty. It was also learnt that the addition of steel fibres into LWC makes it less workable. So for this it was further proposed that the incorporation of steel fibres should in a suitable range. The results from this study led to the conclusion that the mechanical behavior of light weight aggregate concrete was enhanced with the inclusion of steel fibres particularly hardness, split tensile strength and flexural response as compared to conventional concrete. [8]

Behbahani and Nematollahi (2011) on SFRC and suggested that fibres are small, discrete, randomly distributed units which when mixed with conventional concrete increases its tensile strength in contrast to the conventional steel bars .Also it was suggested that of all the available fibres, steel fibres are the commonly used ones. In contrast to the conventional reinforced concrete with steel bars, the fibre reinforced concrete with steel fibres has exhibited unprecedented development in flexural behavior and toughness.[9]

Kim et al (2010) studied the influence of the design mix parameters on the mechanical behavior of aerated lightweight concrete. It was reported that the compressive strength and modulus of elasticity are convincingly influenced by the volume of air present in concrete.

It was also stated that the strength of concrete in compression and the modulus of elasticity are weakly effected by volume of fibre whereas the rigidity is significantly based on the amount of fibres in the aerated concrete. The carbon fibres increases the toughness index to a greater degree as compared to plastic fibre.[10]

Kang& Kim (2010)studied the shear behavior of steel filaments incorporating steel fibres and proposed that the shear strength increased from25%to 45% if the steel fibres are added in the range of 0.5%-0.75%. It was also established by the study that the shear span to depth(effective) ratio largely affects the strength in shear however the shear ability of the concrete members with steel fibres is slightly on the lower side as compared to the routinely used concrete with steel fibres.[11]

Zhang et al (2004) conducted a study on the mechanical properties such as impact strength, flexural rigidity, compressive and tensile stress, Young's modulus of elasticity, of light weight aggregate concrete with or without the fibre reinforcement and found out that there is considerable improvement in the impact strength with the addition of steel fibres to the light weight aggregate concrete. The study also discussed how the density of the aggregates both coarse and fine influences the flexural rigidity and impact strength.[12]

Kayali et.al.(2003)investigated the outcome of mixing steel and plastic fibres in high strength LWAC and reported that the addition of polypropene fibres significantly enhanced the indirect tensile strength by 90 % and bending strength to 20%,while there was no or little effect on other mechanical properties.When compared with the inclusion of steel fibres, it was reported a large increase of 118%in the indirect tensile strength and nearly 80% of bending strength whereas there was a slight decrease in young's modulus.Thus it was concluded that reinforcing LWAC leads to substantial increase in ductile performance.[13]

II. RESULT AND DISCUSSION

The Paper presents the experimental studies done on the LWAC and its response on its mechanical behavior with the inclusion of different types of fibres. This study leads to the following points to hold:

1) To increase the tensile strength of LWAC,it should be reinforced with fibres.
2) Steel fibres on inclusion in LWAC gives the most substantial results.
3) Fibre volume content should be appropriate to get the phenomenal results.

III. CONCLUSION

The above cited experimental studies concludes that incorporating fibres with lower volume fraction will increase the tensile strength of concrete leading to preclude the brittle response of LWAC. Also it has been proclaimed that the steel fibres show a better flexural response in comparison to its behavior in compression and tension. Further it has been learnt that the fibre volume content should be in appropriate range to get the best results. Also it has to be mentioned that steel fibres in LWAC give better response in terms of its mechanical behavior than fibre made of any other material. Therefore, the LWAC should be reinforced with steel fibres in an appropriate fibre volume content to enhance its mechanical behavior and get a better response.

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AUTHORS PROFILE

Ravpreet Kaur, Research Scholar at I.K. Gujral Punjab Technical University, Jalandhar and Assistant Professor at SGT University, Gurugram. She is a Gold medalist in M.Tech Structural Engineering. She is engaged in teaching and research. Her area of research is Steel Fibres.,developing analytical model for different structural systems.

Dr. Harvinder Singh is currently a professor at Guru Nanak Dev Engineering College, Ludhiana. He is engaged in teaching, research and consultancy in structural engineering. He has authored numerous technical publications, one laboratory manual and edited three books. He was granted a research award by the University Grants Commission, New Delhi. He is a state technical auditor and structural consultant involved in various infrastructure projects and is a member of several professional bodies. He is an editorial board member and reviewer for several international journals published by ACI, ICE, and ASCE. His current research interests are mathematical modeling and limit analysis of engineering structures, largely directed towards solving practical problems and improving the related design practices.

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