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A Literature Study of Hybrid Fibre Reinforced Concrete

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ABSTRACT- The drawbacks are that the concrete has been improved by using hybrid fibre in concrete. By hybridization benefits from two different fibres are utilized in a single concrete mixture. The hybrids fibres studied are basalt-polypropylene fibre, polypropylene-steel fibre, steel-coconut fibre, polypropylene-e-waste fibre, polypropylene-polyvinyl Alcohol and steel-glass- polypropylene fibre. The properties that are improved using hybrid fibres are compressive strength, tensile strength, flexural strength, limited crack propagation, and improved durability of the concrete structure. In maximum cases slump value decrease with an increase in fibre percentage.

KEYWORDS- Polypropylene Fibre, Crack Bridging, Hybrid Fibre Reinforced Concrete

I. INTRODUCTION

Five components that are cement, fine aggregates, coarse aggregates, water and air when mix together form concrete. The problem associated with concrete is its weak in tension but good in compression and production of components of concrete i.e. cement cause environmental problems. Another weakness of concrete is crack formation that starts after concrete is placed and is serious issue if cracks are active. Active cracks decrease durability of concrete.

From past 30 years, concrete is reinforced to improve its properties. Reinforcement in concrete improves tensile strength and bridge cracks to enhance durability of concrete structure. Commonly steel is used for reinforcing concrete. But due to weight and cost of steel, alternatives are used. Researchers have proved that few wastes can also be used as reinforcement of concrete that include glass fibre, PET bottles, electronic waste etc. The use of fibre in concrete depends on various facts that are aspect ratio (ratio of length and diameter), geometry. But with inclusion of fibre, properties don't continuously increases. Sometimes it decreases with addition of fibre [6], sometimes after certain amount it decreases [1,2,5]. It's also observed that compressive strength and slump value are opposite [2,5], in such cases admixture are added depending upon type of fibre whether its natural fiber or synthetic fibre. For natural fibre reinforced concrete, mineral admixtures are suggested as waster is absorbed by fibres.

The term hybridization is explained as combination of same fibre of different properties or different fibres of different properties. The benefits of hybridization is that positive impact of two or more fibres are attained in a single concrete mix and when fibre is from waste, it's a great choice from environmental point of view. Figure 1 represents the effect of two different fibres based on length of fibre. Based on length of fibre, fibres are of two types; short fibres and long fibres. Short fibres are also termed as micro fibres or non-structural fibres, its function is bridge small cracks. Long fibres are also termed as macro fibres or structural fibres, its function is to bridge large cracks and also have load carrying capacity. Figure 1 represents the function of fibres based on length.

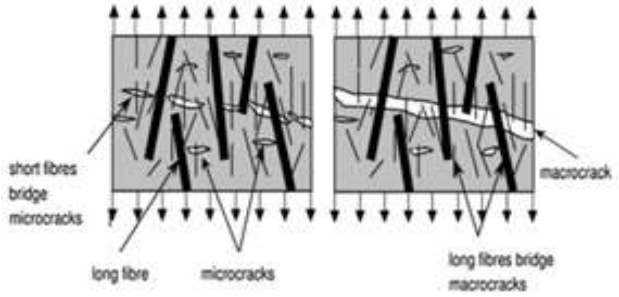

Figure 1: Function of fibres based on length[9]

A. *Crack mechanism*

Figure 2 represents the role of polypropylene fibre in concrete mix where its observed shrinkage cracks occur when stresses due to plastic shrinkage crosses limit of strength [10]. The fibres in a concrete mix act as bridges to connect cracks and to stop propogation of cracks, small cracks are connected by short fibres that are further connected by long fibres, this is how fibres work.

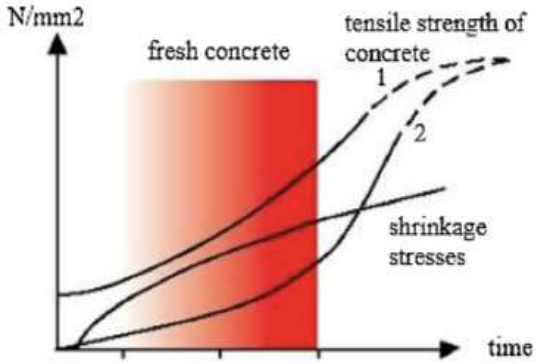

Figure 2: Role of PP fibre in concrete mix [10]

II. LITERATURE REVIEW

A. *Dan-Yang Su [1]*

The study were conducted to analyze the effect of basalt and polypropylene fiber on fly ash concrete for that 16

samples of basalt-PP hybrid fiber fly ash concrete (HBPC) and 1sample as benchmark were casted. The tests performed are slump, static compressive strength, static splitting tensile strength, and dynamic compressive test. The results revealed that both the fibres effect concrete positively, but among the both basalt is more significant for slump and splitting tensile strength whereas Polypropylene is more significant in case of compressive strength. Also it's observed benchmark concrete exhibit brittle failure whereas it changes with addition of fibre in concrete. Bonding of concrete with fibre is analysed with SEM microanalysis where its observed excess fiber may cause agglomeration that will affect bonding of fibre whereas fibre in ideal percentage have good bonding with concrete mix and the random distribution of fibres inside HBPC form stable load carrying structure.

B. Malgorzata Pajak [2]

The study was conducted on self-compacting concrete (SCC) with polypropylene and steel fibres. Slump, compressive and flexural tests were conducted where its observed fresh properties decreases in case of HFRC whereas only steel fibre concrete exhibit satisfying results. Also in case of compressive strength negligible improvement were observed whereas steel fibre plays important role in case of flexural strength and polypropylene plays important role in case of toughness of HFRC.

C. Maged Tawfik [3]

The fibres utilised in the study are polypropylene fibres and steel fibres. The experiments conducted are compressive, tensile and flexural strength at different temperature. The results concluded that compared to one fibre, hybrid fibre show improvement in compressive, tensile and flexural strength at all temperature levels that start from room temperature up to 600° C. the optimum value of fibres are 7% of steel fibre and 0,45% of polypropylene fibre at which 56% rise is observed. Concrete with fibre withstand temperature up to o 600°C whereas concrete without fibre withstand temperature up to 200°C.

D. Navilesh [4]

The fibres utilised in the study are steel fibres and coconut fibres. Steel fibres are used at constant percentage i.e. 1% whereas coconut fibre is used at 1%, 3%, 5% and 7% by volume and slump is conducted to determine fresh properties and compressive, flexural and tensile strength is conducted to determine mechanical properties. All the samples show low workability whereas mechanical properties exhibit improvement compared to normal mix. 1% of coconut fibre is optimum value with improvement in mechanical properties brittle failure also changes into ductile failure.

E. Arooba Rafiq Bhat [5]

The fibres used in the study are E-waste fibre and Polypropylene fibre (PP) at same varying percentage i.e. 0.25%, 0.50%, 0.75% and 1% by weight of cement. To determine fresh properties slump test is conducted and for harden properties compressive strength is conducted for both fibre reinforced concrete (FRC) samples individual. The optimum values of both fibres FRC (0.75% and 0.50% of e-waste fibre and PP fibre) are utilized in a single mix where it's concluded that slump value decreases due to air entrapped with inclusion of fibre and compressive strength increases with addition of fibre due to good bonding between concrete mix and fibres. More amount of fibres lead decrease in compressive strength that may be because of excess fibre content.

F. Dongqing He [6]

Fibres utilised in study are based on elastic modulus i.e. low elastic modulus fibre is PP fibre whereas high elastic modulus fibres are steel, basalt, polyvinyl alcohol (PVA) fibres. The mixes are designed as plain fibre, steel FRC, steel-PPHFRC, Basalt FRC, Basalt-PPHFRC, PVA FRC, PVA-PPHFRC. The combination that has best influence on properties of concrete is steel-PPHFRC after that basalt-PPHFRC whereas PVA-PPHFRC has negative impact on properties of concrete.

G. Kannan.S [7]

The fibres used in the study are crimped stainless steel fibre, glass fibre and polypropylene fibre. The fibres are utilized by volume of cement. In the study it's observed that improvement in mechanical properties is continuous till the optimum values. The optimum values of fibres are 1%, 0.75% and 1% respectively. Also balling effect and heterogeneity is observed at higher fibre percentages.

H. Rajalekshimi J. R. [8]

The study isbased on self-compacting concrete(SCC) where coarse aggregates are partially replaced with crushed bricks of 10-12.5 mm size and the fibres used are PP and steel fibre. The flexural and shear behaviour is studied were its concluded, up to 0.75% and 0.15% of fibre properties increases, after that it decreases because clogging has been started with higher fibre percentage. Also fibre in concrete make concrete stiff that reduced workability. The study have also analysed load deflection behaviour where reduction in cracks is observed with addition of fibres.

I. Rudraswamy M P [11]

The study have concluded effect of fibre on shrinkage of concrete. The fivres utilised in the study are steel fibre, galvanized iron fibres (GIF), high density polyethylene fibres (HDPEF), waste plastic fibre (WPF) and PP fibre with aspect ratio 40 and 100 as hybrid. The study concluded that compared to single aspect ratio, hybrid have exhibited better results as cracks of different sizes are connected by varying length of fibres. Also its concluded that steel fibres exhibit better results among all in terms of crack efficiency and can be used to reinforce concrete.

J. Abdulhameed [12]

The two different fibres utilized in the study are polyvinyl alcohol and steel fibres. The study have developed a stress-strain model with PSO technique was used to understand effect of hybrid fibres clearly. At constant PVA fibre and varying steel fibre, increase is observed in stress capacity.

K. Eswari S. [13]

In the study ductility of concrete is studied using fibres polyolefin and steel fibre. The optimum value obtained is 2% with 30-70 polyolefin-steel fibres. The results concluded that about 80% crack width is reduced with optimum value of fibres, also 98% and 83% improvement was observed in ductility.

III. OBJECTIVES

- To determine the effect of more than one fibre in a concrete mixture.
- To analyse the changes in failure of hybrid fibre reinforced concrete and compare with single fibre reinforced concrete and conventional concrete.
- To determine optimum values of fibres.

IV. CONCLUSION

- It's observed that commonly utilised fibre is polypropylene fibre because of its crack reduction and increase in strength properties.
- Fibre in concrete have maximum times improved mechanical properties whereas fresh property i.e. slump is reverse.
- Reverse behaviour of slump is explained as with inclusion of fibre in concrete air is also entrapped with fibres that lead decrease in slump value but in in medium range of workability still.
- Addition of hybrid fibres has great impact on mode of failure. Mode of failure is completely changed with fibres as fibres bridge cracks and increase durability of structure with mode of failure as ductile that has been changed from brittle failue to ductile failure.
- Mechanical properties has improved with inclusion of hybrid fibre in concrete but higher percentage of fibres reverse the changes in concrete mixture due to weak bonding between higher amount of fibres and concrete mixture.
- Ductility of concrete is also improved by utilizing hybrid fibres in concrete mixture.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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