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USE OF DISCRETE FIBERS IN ROAD CONSTRUCTION: A REVIEW

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Abstract - *The most often utilised building material worldwide is cement concrete. Because it offers exceptional workability and can be moulded to any shape, it is widely used. Ordinary cement concrete has a very low tensile strength, a little amount of ductility, and negligible fracture resistance. microcracks inside the concrete that cause brittle failure. Modern civil engineering projects must fulfil specific structural and durability standards since each structure serves a specific purpose, making modifications to conventional cement concrete a must. It has been discovered that adding certain types of fibres to concrete at particular percentages enhances the structure's mechanical characteristics, durability, and serviceability. It is already well-established that Steel Fiber Reinforced Concrete's (SFRC) high resistance to cracking and fracture propagation is one of the material's key characteristics. By altering the quantity of fibres in concrete, the influence of fibres on the strength of concrete for M 20 grade has been investigated in this work. By cement volume, fibre content was adjusted by 0.50 percent, 1 percent, and 2 percent. In order to test the compressive strength, cubes measuring 150 mm x 150 mm x 150 mm and beams measuring 750 mm x 100 mm x 100 mm were cast. Before being crushed, each specimen was cured for 7, 14, and 28 days. Steel fibre reinforced concrete shows a noticeable gain in strength after 7 days, 14 days, and 28 days of curing, according to research on the outcomes of fibre reinforced concrete with various fibre percentages. The ideal fibre content was determined to be 1% for both the flexural strength of the beam and the compressive strength of the cube. Additionally, it has been noted that when the fibre content rises to its ideal level, concrete strength improves. The Slump Cone Test was used to gauge concrete's workability. The findings of the Slump cone test showed that workability decreases as fibre content increases.*

Key Words: (Concrete, Discrete concrete, road, Utilization of discrete concrete, polyethylene fibre.

1. INTRODUCTION

To prevent cracking caused by shrinkage of the plastic, fibres are typically used in concrete. Additionally, they lessen the permeability of concrete, which in turn lessens water leakage. In concrete, fibres increase impact, abrasion, and shatter resistance. They tighten control over fracture width, minimise the need for steel reinforcement, and increase longevity. Fibers increase structural strength and freeze-thaw resistance. Precast lining segments reinforced merely with steel fibres are used in the majority of tunnelling projects. The goal is to offer suggestions for fibre reinforced concrete constructions like tunnels and bridges in terms of durability and input to service life models. if the mortar binder or concrete matrix has a larger elastic modulus than the fibres. They assist in carrying the burden of raising the material's tensile strength. According to "ACI committee 544," steel fibre reinforced concrete is used as a supplemental material to avoid cracking, enhance resistance to impact or dynamic loading, and prevent material disintegration. Fibers used in concrete have the capacity to absorb more energy.

Pavements made of fiber-reinforced concrete are more effective than those made of regular cement concrete. "FRC is defined as composite material consisting of discontinuous, randomly distributed, evenly spaced short length fibres reinforced concrete." Steel, polymer, or natural materials may be used to make the fibres. In contrast to reinforced cement concrete, which is offered for local strengthening of concrete in tension regions, FRC is thought to be a material with superior qualities. Steel and organic polymer fibres like polyester or polypropylene are the most common fibres used in cement concrete pavements.

1.1 Polypropylene

Giulio Natta and the German chemist Karl Rehn first polymerised propylene to a crystalline isotactic polymer in March 1954. The Italian company Montecatini began mass producing isotactic polypropylene as a result of this groundbreaking discovery in 1957. Syndiotactic polypropylene was also first synthesised by Natta and his coworker.

Polypropylene is one of the cheapest and abundantly availablepolymers. Polypropylene fibres are resistant to most chemical attacks. Its melting point is high (about 165 degrees centigrade). So that it can withstand a working temp, as (100 degree centigrade) for short periods without detriment to fibre properties.

Figure-1: Polypropylene fiber

2. LITERATURE REVIEW

In this review paper, we have studied about the discrete fiber, and conclusion are given below:

Kanalli et.al: PFRC has advantages over traditional concrete pavement. Polyester and polypropylene are two examples of polymeric fibres that are employed because they are affordable and corrosion-resistant. For PFRC to operate at its best, special design considerations and construction techniques are needed. Due to reduced maintenance and rehabilitation costs, PFRC is 30-35 percent less expensive than flexible pavement while having a 15-20% higher starting cost. Road networks in a big, rapidly growing nation like India provide resource movement and communication, which in turn promotes growth and development.

Because resistance to change, no matter how minor, disrupts our society, we are never willing to accept even the best. It's time to push through the obstacles and aim for the summits. The PFRC offers fresh hope for improving and globalising the standard of the "True Indian Roads" and changing their appearance.

Ricky: Polypropylene chips might be converted into polymer fibre using the laboratory mixing extruder (LME) and the Randcastle fiberline (RFL) drawing apparatus. Reliance Industries provided the raw materials for the PP chips and transported them directly from their manufacturing facility in India. Using a two-stage method, a fibre with the desired diameter of 0.5 mm was produced. According to Chapter 3, the extrusion process utilising LME produced an amorphous state fibre with a greater diameter, while the drawing process using RFL produced a crystalline state fibre. To ensure the quality and homogeneity of extruded fibre, machine parameters were improved. However, it was found that the delayed drawing procedure had an impact on the rate of fibre creation.

An effort to alter the fiber's surface in an effort to enhance its performance. The extruded fibre was successfully coated with a thin layer of Aluminum Oxide sol gel, but the pull-out performance of these coated fibres in concrete matrices was subpar. This happened as a result of the coating layer and fiber's adhesive bonding failing during testing. Fiber characteristics were improved by adding silica fume (SF) powder during the fibre extrusion process. The SF co-extruded fibre possessed unique surface roughness, elasticity, and appearance. The extruded polymer's shift in hue was equally intriguing to see.

However, the enhancement of the fiber's surface properties was the most crucial component. During the extrusion process, silica fume particles effectively mixed with the polymer to create an amorphous fibre with a rough surface. The crystalline fibres' surface still displayed this property. Pull-out tests showed that the bonding ability of SF co-extruded PP (SFPP) fibre in concrete matrix was noticeably superior than that of regular PP (RPP) fibre. The enhanced surface roughness of the fibre and probable pozzolanic response were credited with this improvement. The presence of silica on the fiber's surface was verified using SEM.

Rakesh et.al: The following are the main results that were drawn from the experimental work: Multifilament fibre is less effective than fibrillated fibre at reducing concrete settlement. At the same fibre content, it has a less significant impact on slump reduction than multifilament fibre. The 28-day compressive strength of concrete is not adversely affected by the inclusion of multifilament and fibrillated fibre. Concrete drying shrinkage is better controlled by fibrillated fibre than by multifilament fibre. In terms of developing abrasion resistance, concrete with fibrillated fibre performs similarly to concrete having multifilament fibre. Concrete pavements may be built using concrete that has been reinforced with polypropylene fibrillated fibre.

Ahmad: The results of the material test made it clear that adding fibres to plain concrete had a significant impact on its mechanical performance in terms of compressive strength, split tensile strength, and flexural strength. The performance improved as the percentage of fibres increased from 0.5 to 2.0, and the SFRC 2.0 percent performed best of these volume fractions. The addition of 2.0% fibres led to a 44.1 percent improvement in flexural strength. Additionally, the strength of the split tensile and compressive components also rose by 53.3 and 4.8 percent, respectively. Since the fibres span fissures, increasing concrete's capacity to withstand tensile loads, their impact on flexure and tensile strength was more noticeable and effective.

Steel fibre content should ideally be 2.0 percent since it has a significant impact on mechanical performance. Additionally, the literary and business community view the 2.0 percent as a workable and economical percentage. However, greater volume fractions have also been investigated for ultra-high performance concrete, which is an extremely brittle material in comparison to standard plain concrete, up to 3 percent and in some cases 5 percent. It should be noted that this number of fibres reduces the consistency and workability of the concrete, which might be undesirable. As a result, it would be crucial to employ additives to improve the workability. In conclusion, it is thought that using 2.0% fibres by volume of concrete is a sufficient amount.

Mansi, Kartik: One of the most significant and practical characteristics for the building of roads is the compressive strength of bituminous mix. Bitumen is largely used in structural applications to resist compressive loads. Because of this, the qualities of various mix elements that go into generating bituminous mixtures are often quantified in terms of compressive strength. The findings show that adding fibre had a considerable impact on the bituminous mix's characteristics. It is evident that for improving the properties of bitumen from the penetration test results of conventional bitumen & Bitumen with Nylon Fiber that & Bitumen with Nylon Fiber has highest penetration value with 109 cm and from the ductility test results of conventional bitumen & Bitumen with Nylon Fiber that & Bitumen with Nylon Fiber has lowest penetration value with 14 cm. Although the results of the current investigation clearly indicate that nylon fibre influences bitumen properties, it is deemed necessary to expand the current studies using various types of aggregate and binders in order to draw the precise conclusion that the relationships hold true regardless of the constituent types.

Shrikant: It has been noted that as the proportion of steel fibres increases, the workability of steel fibre reinforced concrete decreases. Compressive strength keeps rising as the proportion of steel fibre increases until it reaches its maximum level. One percent was discovered to be the ideal fibre percentage for steel fibre reinforced concrete. With an increase in fibre content, concrete's flexural strength keeps rising until it reaches its maximum level. One percent was discovered to be the ideal number for steel fibre reinforced cement concrete's flexural strength. The plain cement concrete specimens had a normal fracture propagation pattern during testing, which resulted in the breaking of the beam into two pieces. However, the adding of steel fibres to concrete causes the cracking to stop, which causes SFRC to behave ductilely. Although the compression and flexural strengths of flat crimped steel fibre for 28 days are slightly lower than those of hooked steel fibre, they nevertheless have a lower cost (26%) than hooked steel fibre.

Ayyappan et.al: The engineering behaviour of soil-fly ash mixtures was significantly influenced by the presence of fibres. The following are the main findings of our investigation on the engineering behaviour of soil-fly ash mixes with fibre reinforcement. Due to the inclusion of fibres, the moisture-density relationship of soil-fly ash mixes was dramatically impacted. In fly ash and soil-fly ash mixes, the MDD rises and the OMC falls. The soil, however, exhibits a less pronounced reversal tendency.

The peak compressive strength and ductility of soil-fly ash specimens were both improved by the fibre inclusion. The UCS of the unreinforced specimens determines how much the UCS of soil-fly ash specimens increases. As the UCS in the unreinforced condition declines, the relative gain in UCS rises.

While enhancing the ductility or energy absorption capacity of soil-fly ash specimens, an increase in fibre length decreased its contribution to peak compressive strength. For all soil-fly ash specimens, the relative advantage of fibres on CBR values only rises by up to 1.00 percent by dry weight and length up to 12mm. According to the findings of a study on randomly oriented fibre reinforced soil-fly ash mixes, the best performance was obtained using 12 mm fibres at the ideal dosage of 1.00 percent by dry weight of the mixtures.

Sirisha et.al: Over the past seven or eight years, performance concrete has experienced amazing growth. Practically all continents have come to adopt high performance concrete. The technical community seems to have agreed on a broad definition of high performance concrete. Such a definition is predicated on the concrete meeting specific performance standards or qualities for a particular application that are otherwise impossible to get from regular concrete as a commodity product. It is required to employ fibre in various applications. The use of HP-SFRC is still primarily used in the construction of high-rise structures and long-span bridges. In Europe and Japan, it is used more for bridges than for buildings, but in the US, it is utilised more for buildings than for bridges. However, things are evolving. HPC is increasingly being used in structures today. Concrete durability is becoming more important than concrete strength. High strength concrete is frequently utilised for purposes other than those requiring strength because of its high level of durability. The mechanical characteristics of high and very high strength concretes with and without fibres and their structural applications continue to be the subject of much investigation. Several national codes of practise are now incorporating the findings of this research. On the behaviour of the concrete at an early age and its connection to long-term performance, additional knowledge is needed. Two notable recent advancements in the field of high performance fibre reinforced concrete are the Slurry Infiltrated Mat Concrete (SIMCON) and the developed delivery mechanism for non-metallic fibres. The use of continuous fibre reinforcement for enhancing concrete's behaviour has seen substantial interest and development. For prestressed and non-prestressed concrete applications, fibre reinforced polymers (FRP), also known as fibre reinforced plastic, are being recognised as a substitute for uncoated and epoxy-coated steel reinforcement. Western nations have seen an increase in the use of compact reinforced concrete and reactive powder concrete (Ductal).

Finally, only laboratories and research facilities in India are using these high performance new generation fibre concretes. To see it in action, many years will pass.

Sayyed et.al: Direct shear experiments, unconfined compression testing, and traditional triaxial compression tests have shown that the addition of discrete fibres to the soil increases shear strength and decreases post-peak strength loss. The peak shear strength, postpeak strength decrease, axial strain to failure, and, in some situations, the stress-strain behaviour can all be greatly improved by discrete, randomly dispersed fibre inclusions. Additionally, fibre inclusions hinder the compaction process, which lowers the maximum dry density of reinforced specimens as their fibre content increases. With fibre reinforcement, the strength losses brought on by in-service saturation are greatly decreased. Overall, it is important to note that there has been less study on the use of fibres with cohesive soils. Although it has been noted that fibre reinforcement increases the strength of cohesive soils, further research is required to fully assess this reinforcement since it is unclear how loads are transferred across the interface between fibres and clayey soils. The combined impact of fibre and various chemical binders (such as fly ash, cement, lime, poly vinyl acetate, poly vinyl alcohol, and urea formaldehyde) on granular or clayey soils has lately attracted the attention of several researchers. The primary explanation is that while chemical binders increase soil stability, they also reduce the soil's ductile nature. In this approach, fibres aid in lowering the composite soil's brittleness factor. As a result, a brittleness factor with a scale of 1 to 0—where 0 denotes fully ductile behavior—was established in this study. The authors come to the conclusion that the three main executive issues with the short composite soil manufacturing are the absence of scientific standards, clumping and balling of fibres, and adherence of fibre to soil.

The advantages of short fibre composite soils are that they are readily available, affordable, quick and simple to use, and practical in all weather situations. The use of fibres in soil reinforcement has several technical advantages, such as preventing the development of tensile cracks, increasing hydraulic conductivity and liquefaction strength, decreasing thermal conductivity and building material weight, reducing the tendency of expansive soils to swell, and reducing soil brittleness. The use of natural and/or synthetic fibres in geotechnical engineering has also demonstrated to be practical in six disciplines, including pavement layers (road construction), retaining walls, earthquake engineering, railway embankments, slope protection, and soil-foundation engineering.

Ravindra et.al: A cement-bound road base with fibre reinforcement has the potential to perform better by extending the base's fatigue life and strengthening its ability to withstand reflective cracking of the asphalt. The experiments also show that hardened SFRCC's qualities, such flexural strength, are noticeably superior to those of traditional RCC. Therefore, it is possible to recommend positively the use of steel fibre for efficient pavement construction.

James et.al: In Portland cement concrete, naturally occuring reinforcing elements can be employed successfully as reinforcement. For poor nations, natural fibre reinforced concrete is ideal since it may be used for inexpensive construction. The usage of indigenous materials must be strongly pursued by researchers, design engineers, and the building sector. Natural fibre reinforced concrete is a feasible alternative for cost-effective technical solutions to a range of issues, and it has to be thoroughly explored and utilised. Asbestos has been effectively replaced by wood fibres obtained from the Kraft process, which offer very desirable performance-to-cost ratios, in the manufacture of thin-sheet cement products including flat and corrugated panels and nonpressure pipes.

Manoj, Ganesh: The volume fraction of 0.2 percent, 0.4 percent, 0.6 percent, 0.8 percent, and 1 percent of Polypropylene fibre, Polyvinyl alcohol fibre, and Recron 3s fibre combinations were used to make the M35 grade of synthetic hybrid fibre reinforced concrete using a 0.41 water to cement ratio. The compressive strength of PP 0.4 percent, PVA 0.4 percent, and Recron 0.6 percent, the tensile strength of PP 0.4 percent, PVA 0.4 percent, and Recron 0.6 percent, and the flexural strength of PP 0.4 percent, PVA 0.4 percent, and Recron 0.6 percent were observed to be obtained as the maximum strength, then the strengths will decrease as the fibre content increases.

Deepa et.al: The results of various laboratory investigations are listed below, and they are discussed as follows: It is understood that adding fibres to the concrete mix influences new concrete's slump value, compressive strength, and flexural strength. The table shows how the presence of steel fibre influences the hardened qualities of concrete mix, including its 28-day compressive strength. It is clear that the compressive strength of concrete mixes increases up to the addition of 1% steel fibres before gradually declining after that. While the compressive strength of a mix with 2% steel fibres is higher than that of a mix with 1% steel fibres, from an economic standpoint, it is much more expensive. The addition of steel fibre demonstrates a consistent improvement in flexural strength with an increase in steel fibre content. The maximum is two percent, although from an economic standpoint, two percent mix costs more than one percent mix does. Because the modulus of elasticity of the specific mix increases as the fibre content does, it is observed that the radius of relative stiffness increases with an increase in fibre content in concrete mixes up to 1 percent, reaching 338378.48 kg/cm2 for R3 mixes, which is higher than the value of R0 mixes, which is only 317411.4 kg/cm2. Higher compressive strength and a solid matrix bond, which cause the bond to endure less strain for a given load, are the major causes of this rise. The ideal slab thickness, or 1 percent of fibre, is being reached since mechanical qualities of fibre rely on factors including fibre form, quantity, and aspect ratio. The ratio of the corrugated fiber's length (30 mm) to thickness determines the aspect ratio, which is calculated as having a value of 42. (0.7 mm). The outcome indicates that, when compared to conventional concrete, the thickness achieved at 1 percent is optimal, or 33.5 cm (37 cm). According to the experiment, the proportion of fibres increases together with the concrete section's capacity to withstand temperature stress. As temperature stress is primarily influenced by the area's temperature difference, concrete's modulus of elasticity, thermal expansion coefficient, and coefficient of temperature differential. Here, the practical coefficient of thermal expansion and temperature differential are constant, but the elastic modulus and concrete mix have changed, and the value of the coefficient of temperature differential has also changed because it depends on the value of the radius of relative stiffness, which has decreased by up to 1%. There is a variation in the stress caused by temperature change. According to the experiment, the corner region experiences the most stress since it is discontinuous in both directions. Wheel load, slab thickness, radius of contact area, and radius of relative stiffness are the key factors influencing corner stress.

Vijay: Steel and polypropylene fibres can be added to conventional concrete to enhance its mechanical properties. We can draw the conclusion that steel and polypropylene fibres can be used to increase the durability of conventional concrete. The ideal dose for polypropylene fibres is 0.3 percent, whereas the ideal dosage for crimped steel fibres is 1.5 percent. Compared to polypropylene fibres, concrete reinforced with crimped steel fibres performs better.

Krushna et.al: Concrete's ductility and load-carrying ability were both increased by the inclusion of fibre in reinforced concrete. In comparison to the other two mixes, which contain 3% each of polyester and polypropylene fibre, the compressive strength of regular concrete is lower. The split tensile strength and flexural strength tests are also equivalent. Compared to polypropylene fibre, polyester fibre has a higher strength. It is less expensive and ought to be practical. Polyester and polypropylene fibre were used without any workability issues. Concrete with fibre reinforcement is resistant to cracking and distortion.

Shilpa, Mrudula: Maximum flexural and compressive strength can be attained with very little cost increase by combining 0.3 percent polypropylene fibres, 2% steel fibres, and 0.3 percent synthetic fibres. It is simple to study the differences between regular concrete and fibre reinforced concrete after slabs have been cast and have had time to cure for 28 days. The crack arresting phenomena shown is noticeably amplified when 0.3 percent of polypropylene fibres are added to regular concrete.

3. CONCLUSION

The Normal Concrete Mix has a lower compressive strength than the other three mixes, but the Polyester and Polypropylene Concrete Mix has the highest compressive strength. Normal concrete had a lower flexural strength than the other three mixes, however mixtures containing both polypropylene and polyester and 0.5 percent polyester exhibited a significant improvement in flexural strength. Only the concrete with 5% polyester fibre and the blend of polypropylene and polyester enhanced the strength of the normal concrete mix, which has a lower split tensile strength than the other three. When polyester fibre was added to concrete, the strength increased significantly compared to polypropylene fibre. The strength increase in concrete mixes containing polyester fibre and those containing both polyester and polypropylene fibre is not significantly different.

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