INFLUENCE OF FIBRE REINFORCEMENT ON STRENGTH AND TOUGHNESS OF LIGHT WEIGHT CONCRETE

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***Abstract*: The usefulness of fiber reinforced concrete (FRC) in various civil engineering applications in indisputable. FRC has so far been successfully used in construction of structure like slab, bridge, industrial structure and many other applications. In this work, partial replacement of pumice light weight aggregate is carried out. The light weight aggregate concrete can increase the economic efficiency by reducing the self weight and dimensions of the structure. In this work the polypropylene fibers are added with concrete with different ratio (0.5 %, 1%, 1.5%, 2%) to identify the split tensile strength, compressive strength, flexural strength, and flexural toughness by ASTM C1018 method.**

Index Terms: FRC - fiber reinforced concrete, polypropylene fibers

1.1 GENERAL

Concrete is a composite material composed of coarse granular material (the aggregate or filler) embedded in a hard matrix of material (the cement or binder) that fills the space between the aggregate particles and glues them together. Concrete as a composite material that consists of a binding medium within which are embedded particles or fragments of aggregates. concrete is strong in compression but weak in tension.The simplest representation of concrete is: Concrete = Filler + Binder.According to the type of binder used, there are many different kinds of concrete. For instance, Portland cement concrete, asphalt concrete, and epoxy concrete. In concrete construction, the Portland cement concrete is utilized the most.

1.1.1 POLYPROPYLENE FIBER REINFORCED CONCRETE

Concrete modification by using polymeric materials has been studied for the past four decades. In general, the reinforcement of brittle building materials with fibres has been known from ancient period such as putting straw into the mud for housing walls or reinforcing mortar using hair etc. Many materials like jute, bamboo coconut, rice husk, cane bagasse, and sawdust as well as synthetic materials such as polyvinyl alcohol, polypropylene (pp) etc. have also been used for reinforcing the concrete. Research and development into new fibre reinforced concrete is going on today as well. Concrete made with potland cement characteristics: it is relative strong in compression but weak in tension and tends to be brittle. These two weaknesses have limited its use. Another fundamental weakness of concrete is that cracks start to form as soon as concrete is placed and before it has properly hardend. These cracks are major cause of weakness in concrete particularly in large onsite applications leading to subsequent fracture and failure and general lack of durability. The weakness in tension can be overcome by the use of conventional rod reinforcement and to some extent by the inclusion of a sufficient volume of certain fibres. Polypropylene fibres are chemically iner, and so will not rust, corrode or rot, and will not absorb water. The introduction of polypropylene fibres in concrete affects its properties both in fresh and hardened state. In fresh state it may reduce the workability and the also slows down the rate of bleeding .It may also increase the setting times for the concrete. Like any secondary reinforcement, the short discrete fibres tend to mitigate the crack propagation by bridging the cracks and providing increased resistance to crack propagation. The structure of the fibrillated polypropylene fibres is such that it provides three dimensional reinforcement to the cementitious matrix. Thus enhancing tensile strength, tensile strain capacity and the improved resistance to cyclic and fatique. Its use enables reliable and effective utilization of intrinsic tensile and flexural strength of the material along with significant reduction of plastic shrinkage cracking and minimizing of thermal cracking. Since then the use of these fibres has increased tremendously in construction of structures because addition of fibres in concrete improves the toughness, flexural strength, tensile strength and impact strength as well as failure mode of concrete.

1.2 ADVANTAGES OF CONCRETE

1.2.1 Economical

Concrete is the most inexpensive and the most readily available material. The cost of production of concrete is low compared with other engineered construction materials. Three major components: water, aggregate and cement. Comparing with steel, plastic and polymer, they are the most inexpensive materials and available in every corner of the world. This enables concrete to be locally produced anywhere in the world, thus avoiding the transportation costs necessary for most other materials.

1.2.2 Ambient temperature hardened material

Because cement is a low temperature bonded inorganic material and its reaction occurs at room temperature, concrete can gain its strength at ambient temperature.

1.2.3 Ability to be cast

It can be formed into different desired shape and sizes right at the construction site.

1.2.4 Energy efficiency

Low energy consumption for production, compare with steel especially. The energy content of plain concrete is 450-750 kWh / ton and that of reinforced concrete is 800-3200 kWh/ton, compared with 8000 kWh/ton for structural steel.

1.2.5 Excellent resistance to water

Unlike wood and steel, concrete can harden in water and can withstand the action of water without serious deterioration. This makes concrete an ideal material for building structures to control, store, and transport water. Examples include pipelines (such as the Central Arizona Project, which provide water from Colorado river to central Arizona. The system contains 1560 pipe sections, each 6.7 m long and 7.5 m in outside diameter 6.4 m inside diameter), dams, and submarine structures. Contrary to popular belief, pure water is not deleterious to concrete, even to reinforced concrete: it is the chemicals dissolved in water, such as chlorides, sulfates, and carbon dioxide, which cause deterioration of concrete structures.

1.2.6 High temperature resistance

Concrete conducts heat slowly and is able to store considerable quantities of heat from the environment (can stand 6-8 hours in fire) and thus can be used as protective coating for steel structure.

1.2.7 Ability to consume waste

Many industrial wastes can be recycled as a substitute for cement or aggregate. Examples are fly ash, ground tire and slag.

1.2.8 Ability to work with reinforcing steel

Concrete and steel possess similar coefficient of thermal expansion (steel 1.2 x 10-5; concrete 1.0-1.5 x 10-5). Concrete also provides good protection to steel due to existing of CH (this is for normal condition). Therefore, while steel bars provide the necessary tensile strength, concrete provides a perfect environment for the steel, acting as a physical barrier to the ingress of aggressive species and preventing steel corrosion by providing a highly alkaline environment with pH about 13.5 to passivate the steel.

1.2.9 Less maintenance required

No coating or painting is needed as for steel structures.

1.3 LIMITATIONS OF CONCRETE

1.3.1 Quasi-brittle failure mode

Concrete is a type of quasi-brittle material. (Solution: Reinforced concrete)

1.3.2 Low tensile strength

About 1/10 of its compressive strength. (Improvements: Fiber reinforced concrete; polymer concrete)

1.3.3 Low toughness

The ability to absorb energy is low. (Improvements: Fiber reinforced concrete)

1.3.4 Low strength/BSG ratio (specific strength)

Steel (300-600)/7.8. Normal concrete (35-60)/2.3. Limited to middle-rise buildings. (Improvements: Lightweight concrete; high strength concrete)

1.3.5 Formwork is needed

Formwork fabrication is labour intensive and time consuming, hence costly (Improvement: Precast concrete)

1.3.6 Long curing time

Full strength development needs a month. (Improvements: Steam curing)

1.3.7 Working with cracks

Most reinforced concrete structures have cracks under service load. (Improvements: Prestressed concrete).

1.4 CLASSIFICATION OF CONCRETE

Based on unit weight Ultra-light concrete <1,200 kg/m3 Lightweight concrete 1200- 1,800 kg/m3 Normal-weight concrete ~ 2,400 kg/m3 Heavyweight concrete > 3,200 kg/m3 Based on strength (of cylindrical sample) Low-strength concrete < 20 MPa compressive strength Moderate-strength concrete 20 -50 MPa compressive strength High-strength concrete 50 - 200 MPa compressive strength Ultra high-strength concrete > 200 MPa compressive strength Based on additives:Normal concrete, Fiber reinforced concrete, Shrinkage-compensating concrete, Polymer concrete.

1.5 FIBRE REINFORCED CONCRETE

Concrete is very brittle in nature with the consequent low crack resistance which have limited its use only to absorbing compressive stresses. The idea of adding additives to concrete to improve its strength have been employed for many centuries. Concrete additives have been used since roman and egyptin times,when it was discovered that adding volcanic ash to the mix allowed it to set underwater, while adding horse hair made concrete less liable to crack and the adding of blood made it more frost-resistant. In the most recent times, many methods have been adopted to improve concrete properties, and one of such methods is the addition of fibers to concrete. For over half a century, extensive researches were undertaken to determine the appropriate qualities of fibres needed for various applications. The qualities of fibers needed for fibre reinforced concrete has been one of the major topics of interest because of the importance of concrete to the construction industries .Various types of fiber materials such as steel, corbon , glass, plastic, polypropylene , nylon, and cotton were tested. synthetic fiber such as polyester ,acrylic , polyethylene and polypropylene are further subdivided into micro – synthetic fibres (for diameter less than 0.30 mm) and macro – synthetic fibres (for diameter greater than 0.3mm).Glass and natural fibres shows vulnerability to temperature variation and environmental conditions , respectively , leaving steel and synthetic fibres as the most viable concrete reinforcement options. Generally, the introductions of fibres into the concrete mix have proved to considerably improve the ductile behavior of concrete materials. Under pure compressive loads and low tensile stress, the addition of fibres has little effect. This significantly improves the crack control as it reduces the crack width and crack spacing in the concrete which in turn reduces thr ingress of water and chemicals that are know to be harmful to concrete thereby improving the long term serviceability and durability of built structures. The reduction of crack growth through the adoption of fibres is comforting news to the building industry as many infrastructures are beginning to age . Fibres in concrete have proved useful in controlling crack growth by inhibiting plastic and drying shrinkage from taking place thereby reducing the permeability of concrete. The application of fibre reinforced concrete are indispensable in all concrete construction under mixted and heavy loadings and where tensile stresses are common such as roadways ,warehouses , driveways, side walks, runways , taxiways , dams ,storm-water structures ,minning and tunneling structures , storage structures, etc .

1.6 OBJECTIVES OF THE PROJECT

Light weight aggregate (pumice) is one of the best emerging replacement of coarse aggregate in modern construction industry in concrete. This project aims at meeting the future demands on the use of coarse aggregate by partial replacing light weight aggregate pumice without sacrificing the quality. The objectives is to investigate the feasibility and potential use of polypropylene fibre and light weight aggregate pumice in concrete application. Towards this , it is planned to study the replacement of coarse with partial replacement of light weight aggregate (pumice) as a substitute for coarse aggregate in concrete with different polypropylene ratio of 0.5% – 2 %.It is also proposed to study the flextural behaviour of beams and also the bond strength behaviour made replacement of coarse with partial replacement of light weight aggregate pumice as a substitute for coarse aggregate in concrete with different polypropylene ratio of 0.5% – 2 %.

1.7 SCOPE OF THE PROJECT

The main objectives of this project are

i. To study the literature review
ii. To develop the polypropylene Fibre Reinforced Concrete Of M30 grade
iii. To find the optimum strength of the partial replacement of light weight aggregate pumice.
iv. To study the behavior of beams in flexure and also to compare with control beams.

2.1 REVIEW OF LITERATURE

Mohammad Abdur Rasheed et al (2019) The objective of this study is to develop a high performance fiber reinforced cellular concrete to provide a better alternative than aerated autoclaved concrete blocks for structural applications of masonry. Use of micro-fibers (fibrillated) enhances pre-cracking behavior of masonry by arresting cracks at micro-scale, while macro (structural) fibers induce ductile behavior in post-peak region by arresting the crack propagation soon after the crack initiation. Test results indicate that the addition of structural fibers improved the compressive strength up to 66.8% for 0.55% volume fraction. Post-peak ductility improved up to a factor of nine in case of compression for 0.55% volume fraction. Similarly, it resulted in 15.31% increase of post-peak flexural ductility by a hybrid addition of 0.44% and 0.02% volume fraction of macro and micro fibers respectively. Compressive strength increased progressively with addition of macro fiber dosage. It increased up to 52.6% for 0.22% and up to 66.8% for 0.55% volume fraction when compared to that of control specimen. Increase in strength is not proportional to increase in fiber dosage. There The compressive toughness index increased by a factor of 6.7 for 0.22%, 7.7 for 0.33%, 9.4 for 0.44% and 9.0 for 0.55% volume fraction addition of macro fiber. Due to addition of macro-fibers, the flexural strength increased up to 11.7% for 0.22% and up to 46.7% for 0.44% volume fraction. With further addition of micro-fibers of 0.2 kg/m3 to 0.44% volume fraction, the flexural strength increased up to 69.6%. This indicates that the hybrid reinforced specimens performed better compared to the specimen with only macro structural fibers. Increase in stiffness and the peak flexural load resulted in the increment under the area of load–displacement curve which led to increase in toughness index This can be attributed to the synergetic role played by fibers in bridging the cracks.

Peter Donkor (2019) The research discussed in this paper assessed the feasibility of improving the strength and deformability of CEBs with polypropylene fibers while meeting or exceeding minimum thresholds in applicable codes. The inclusion of the fibers improved block ductility and deformability. Over all, increasing fiber fraction up to a fiber weight proportion of 0.6% resulted in an enhancement in strength compared to the unreinforced CEBs. Both compressive strength and 3-point bending strength were improved by 22.5% and 22.0% respectively at 0.4% fiber content. Mixing became more difficult and strength began to decline as the fiber weight fraction exceeded 0.6%. It is therefore recommended not to exceed 0.6% polypropylene fiber weight content for CEB production. An ideal range of polypropylene fibers to add to CEB matrices is between 0.4% and 0.6%.the polypropylene fibers used are a feasible fiber option for CEB production and at an optimum dosage, can be used to enhance the strength, ductility, and deformability of soil– cement matrices used for CEB production. Improvement in these properties at the block level coupled with good construction practices can ultimately result in performance improvement at the system level.

Arabi N.S et al (2019) This experimental study investigates the effect of specimen shape on residual mechanical properties of polypropylene (PP) fibre self-compacting concrete (SCC) exposed to elevated temperatures from 200 to 600 ◦C. The cubical specimens show a better residual compressive strength than cylindrical specimens that means it is easy for the temperature to transfer from the surface of cylindrical specimen to the centre and there is a symmetrical distribution of heat more than it is observed in the cubical specimen as the distance from the edge is greater than the other side of the cube thus the distribution of heat is irregular. Physically there is a difference of 25% in the compressive strength between cubical and cylindrical specimens. This could advice to avoid symmetrical shapes in the building and using columns with cubical shape is better than cylindrical one.

Flores Medina.N et al (2019) Concrete composites containing natural pozzolan (toba trachite), point shaped crushed aggregates and different fiber volume fractions of PPF (0.03%, 0.06%, 0.09%, and 0.12%) were studied. The cracked area due to drying shrinkage was measured to establish the positive effect of the different PPF volume fractions in concretes. Besides, bulk density and water permeability depth were determined. The results indicate that a volume fraction of 0.07% of PPF reduces cracking area due to drying shrinkage of NPC a 66%, but larger volume fractions did not increased linearly this effect, and even worse results were obtained. The increment of PPF volume fraction reduces the water permeability depth and even the carbonation depth. A reduction of the cracked area, due to early shrinkage, of a 66% in NPC concretes may reach in these concretes a 32% lower water permeability indicators (enclosed wet area) and a 43% shorter minimum carbonation depth attending to the results obtained. In conclusion NPC concretes with low amounts of PP fibers (upper to 0.07% volume fraction) are less permeable and the CO2 diffusion is slower in time due to early age cracking control, producing more durable concretes. PPF showed early age cracking control ability, reducing the total cracked area and the length of cracks .Larger amounts of PPF did not improve cracking control ability. NPC concretes with low amounts of PPF are less permeable and the CO2 diffusion is slower. Mixtures with PPF have shown a better performance although they present lower US modulus and density. NPC concretes with low amounts of PPF can be more durable in time than plain concrete, because they are less permeable and the CO2 diffusion is slower in time due to early age cracking control.

Jagadeesh K.A (2018) In this paper the normal concrete is weak in initial shrinkage where as introduction of Fibres to concrete decreases its initial shrinkage and also imparts strength to concrete later on stage. The SCC is made with 20% replacement of cement with silica fume and varying percentage Polypropylene fibres from 0% to 0.2% i.e., 0%, 0.05%, 0.1%, 0.15%, 0.2% to the total volume of concrete along with addition of super plasticizer 0.6% to the volume of cement content for M30 and M35 mix designations. The main focus of this study will be on investigating maximum percentage of replacement Polypropylene Fibres that can be made added to total volume of concrete to attain maximum value of both compressive and flexural strength and to study the flexural behaviour of beams with and without reinforcement. In the fresh state of concrete as the percentage of fibres increases slump flow value decreases. In the hardened state of concrete there is no considerable increase in compressive strength of concrete, but there is a noticeable increase flexural strength of concrete by the addition of Polypropylene fibres. In the hardened state of concrete there is an overall increase in strength of concrete both in compressive and flexural strength for the 0.1% addition Polypropylene fibres.

Jisun cnoi et al (2018) The effect of fiber reinforcement on all-lightweight concrete in which both fine and coarse aggregates are artificially lightweight was investigated experimentally. Three different fibers (i.e., steel, vinylon and polyethylene) were compared for their effects on the compressive strength, splitting tensile strength, flexural strength, shear strength, and toughness. Using 1.5% vinylon fibers significantly improved the flexural strength of the all-lightweight concrete 234% higher than that of normal concrete. Using 1.2% steel fiber increased the fracture toughness of the all-lightweight concrete more than twelve times. lightweight aggregate concrete, can increase economic efficiency by reducing the self-weight and dimensions of the structure. Polypropylene fibers have been found to double the splitting tensile strength of concrete. The main objective is to determine the improvement in strength and toughness of an all-lightweight concrete through the addition of three different types of commonly used short fibers: steel (ST), vinylon (V), and polyethylene (PE).both the coarse and fine aggregate were 100% artificial. The artificial light weight aggregates were asan olite aggregate made from expanded shale.Adding fibers improved the flexural strength even more significantly than the splitting tensile strength. Vinylon fibers improved the flexural strength of the all-lightweight concrete most efficiently followed by polyethylene and steel fibers. The flexural strength of the normal concrete was also improved with the addition of fibers, but the strength increase was around 60%, which was less efficient than for the all-lightweight concrete Steel fibers were the most effective to increasing the toughness of both the all-lightweight and normal concrete. The residual strength of the normal concrete was greatly improved even with a lower fiber volume.

Kumar D (2018) The new particle – reinforced composites has been developed using defatted horn fibre (HF) and polypropylene (PP) .Physical .mechanical, thermal and micro – structural properties of HF/PP composites with varying fibre wt% (5%,10%,15%,and 20%) heve been characterized and compared with the properties of pure pp and pure HF.Mechanical properties of pure HF are found to be very high compared to pure PP and HF/PP composites.Compared to pure PP , HF/PP composites show an increase in , tensile yield strength slightly , tensile modulus by 15.74% , flexural strength by 16.95% and flextural modulus by 59.69% and decrease in ultimate tensile strength by 15.03% , percentage elongation at break and impact strength to a considerable amount.Melt flow index for HF/PP composites decreases with increase in fibre contant.Thermogravimetric analysis reveals that there is an increase in thermal stability of HF/PP composites with increase in fibre contant.The horn and HF/PP composites with low density and good properties can find application in fields like automobile , computers , construction , house ware.etc.Pure HF consists of carbon,nitrogen and molybdenum with maximum carbon wt% .Iron , sodium , chlorine are also present in smaller amounts.Compared to pure PP,increase in tensile yield strength , tensile modulus , flexural strength , flexural modulus and decrease in ultimate tensile strength and impact strength is due to increase in stress concentration points of hard HF particles and clustering of fibre particles with increase in fibre loading.Good compatibility between the fibre particles and pp has been noticed up to 15 wt% of HF/PP composites.The use of bio-waste fibre for composite manufacturing reduces environmental pollution , replaces synthetic fibres and is cost effective.

Vinay Kumar Singh (2018) In order to improve these properties of plain concrete, an attempt has been made to study the effect of addition polypropylene fiber in ordinary portland cement concrete. The results have shown improvement in compressive strength and flexural strength with the addition of polypropylene fiber in ordinary portland cement concrete The fiber content is vary from 0.1%, 0.3%, 0.5% and 0.7% by weight of concrete. Compressive strength increases with increasing percentage of fibers. It can be observed that 28 days compressive strength is increased by 1.23% with addition of 0.05% of fiber compared to normal M-25 concrete. It can be observed that 28 days compressive strength is increased by 4.55% with addition of 0.15% of fiber compared to normal M-25 concrete. It can be observed that 28 days compressive strength is increased by 4% with addition of 0.25% of fiber compared to normal M-25 concrete. Also it can be observed that 28 days compressive strength is increased by 2.44% with addition of 0.35% of fiber compared to normal M-25 concrete. 0.5% addition of fibers into the concrete shows maximum benefits in compressive strength. Flexural strength increases with increasing percentage of fibers. It can be observed that 28 days flexural strength is increased by 7.29% with addition of 0.05% of fiber compared to normal M-25 concrete. It can be observed that 28 days flexural strength is increased by 43.52% with addition of 0.15% of fiber compared to normal M-25 concrete. It can be observed that 28 days flexural strength is increased by 51.05% with addition of 0.25% of fiber compared to normal M-25 concrete. Also it can be observed that 28 days flexural strength is increased by 46.35% with addition of 0.35% of fiber compared to normal M-25 concrete. 0.25% addition of fibers into the concrete shows maximum benefits in flexural strength.

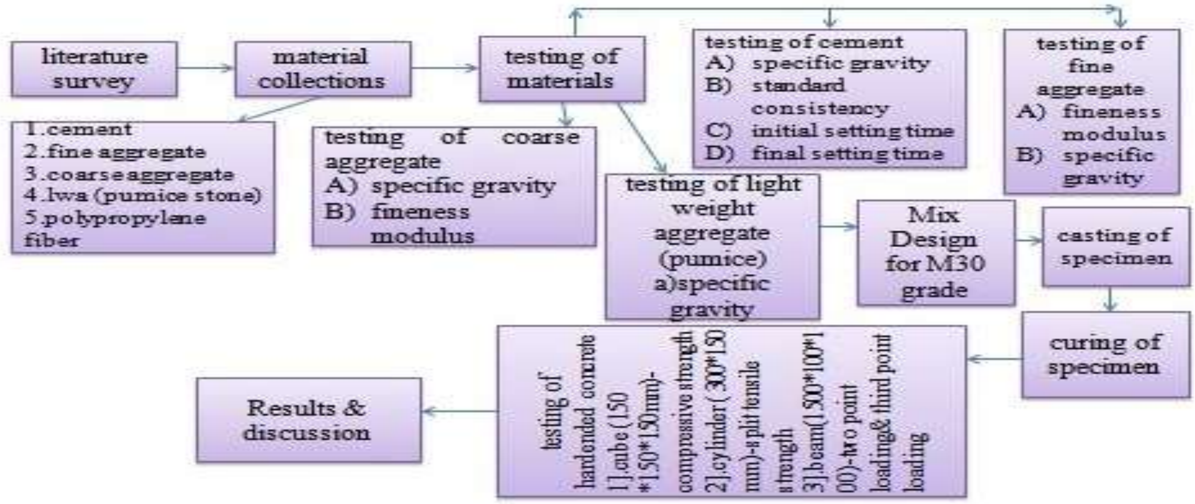
Angel M. et al (2017) Surface treatments on a polypropylene (PP) fiber have contributed to the improvement of fiber/concrete adhesion in fiber-reinforced concrete. The treatments to the PP fiber were characterized by contact angle measurements, ATR-IR and XPS to analyse chemical alterations. The surface topography and fiber/concrete interaction were analysed by several microscopic techniques, namely optical petrography, and scanning electron microscopy. Treatment modified the surface chemistry and topography of the fiber by introducing sodium moieties and created additional fiber surface roughness. Modifications in the fiber surface led to an increase in the adhesion properties between the treated fibers and concrete and an improvement in the mechanical properties of the fiber-reinforced concrete composite as compared to the concrete containing untreated PP fibers. Compatibility with the concrete and increased roughness and mineral surface was also improved by nucleated portlandite and ettringite mineral association anchored on the alkaline PP fiber surface, which is induced during treatment. The alkaline surface treatment on PP fibres imparts roughness and chemically modifies the surface of PP fibres. Untreated PP fibre shows poor adhesion to mortar. The surface treatment on PP fibres increases adhesion to mortar. Concrete without PP fibres only resists the first bending load. The concrete containing PP fibres resists the second and third bending loads. Flexural strength is increased for concrete containing treated PP fibres. Moreover, treated PP fibres act as anti-cracking agents impeding the propagation of cracks once load is applied.

Roohollah Bagherzadeh et al (2016) The influence of polypropylene fibers has been Studied in different proportioning and fiber length to improve the performance characteristics of the lightweight cement composites. Fibers used in two different lengths (6mm and 12mm) and fiber proportions (0.15% and 0.35%) by cement weight in the mixture design. Compared to unreinforced LWC, polypropylene (PP) reinforced LWC with fiber proportioning 0.35% and 12 mm fiber length, caused 30.1% increase in the flexural strength and 27% increase in the splitting tensile strength. Increased fiber availability in the LWC matrix, in addition to the ability of longer PP fibers to bridge on the micro cracks, are suggested as the reasons for the enhancement in mechanical properties. This study was to evaluate the action of PP fibers at different volume fractions and fiber length to obtain a good physical and mechanical behavior of light weight concrete. Fibers with two different length, 6mm and 12mm were employed for this study. Fiber reinforcement significantly increases the tensile strength of lightweight aggregate concrete. The higher tensile strength along with the higher flexural strength is believed to be effective in reducing shrinkage in lightweight aggregate concrete. All reinforced lightweight concrete specimens display improvement in their mechanical strength as a result of fibers performance in cement matrix.

2.3 SUMMARY OF LITERATURE REVIEW

There are very few literatures are available in the effect of the performance of polypropylene fiber reinforcement on strength and toughness of light weight concrete. In a review of the above researches, the possibility of construction waste materials to produce normal concrete and high strength concrete when used as a partial or whole replacement of aggregate become evident. Though a large number of significant results have been reported on the use of polypropylene fibers in concrete , there is not much literature available on the use of light weight aggregate (pumice) as partial replacement of coarse aggregate , with even less literature available on the use of LWA (pumice) as partial replacement of coarse aggregate. However , the effects of furnace LWA with PPF on workability , compressive strength , split tensile strength , flexural strength of concrete were investigated. The volcanic material pumice is becoming wide spread and their use as construction materials can lead to low cost construction. Investigation on reinforced concretes made with lightweight aggregate pumice revealed their satisfactory resistance against salt attack/steel corrosion and their suitability of using in load – bearing and enclosure structures.

3. METHODOLOGY



4. MATERIALS PROPERTIES

4.1 MATERIALS USED

The materials used for this study are given below, Cement, Fine aggregate, Coarse aggregate, Light weight aggregate pumice, Polypropylene fibre, HYSD bars, Water. The detailed description of the materials and their properties are discussed below.

4.2.1 Portland pozzolanic cement

Cement is a fine grey powder .It is mixed with water and materials such as sand, gravel and other crushed stone to make concrete. The cement and water from a paste that binds the other materials together as the concrete hardens. Standard consistency, initial setting time tests were done for this cement. The percentage composition is given below in table 4.1.

Table 4.1 cement constituents

Constituents	Percentage (%)
CaO	63.1
SiO_2	19.8
Al_2O_3	4.9
Fe_2O_3	2
MgO	2
Na_2O	0.85
CO_2	1.89

Table 4.2 Physical properties of cement

S. no	Physical properties of cement	Result
1	Specific gravity	3.15
2	Standard consistency	28%
3	Initial setting time	35 min
4	Final setting time	492 min
5	Fineness	10

Above the following tests were conducted in accordance with IS codes .

- Specific gravity (IS : 4031 – 1988 Part 11)
- Fineness (IS : 4031 – 1996 Part 1)
- Standard consistency (IS : 4031 – 1988 Part 4)
- Initial setting time (IS : 4031 – 1988 Part 5)
- Final setting time (IS : 4031 – 1988 Part 5)

4.2.2 Fine aggregate

Aggregate which passed through 4.75mm IS sieve and retained on 75micron (0.075 mm) IS sieve is termed as fine aggregate. Fine aggregate is added to concrete to assist workability and to bring uniformity in mixture. Fine aggregates can be natural or manufactured. The grading must be uniform throughout the work. The fine aggregate used in investigation was clean river sand and above the following tests were carried out on sand as per IS:2386 – 1968 (I & II).

- Specific gravity
- Fineness modulus

Table 4.3 Physical properties of Fine aggregate

S. no	Property	Fine aggregate
1	Fineness modulus	3.47
2	Specific gravity	2.62

4.2.3 Coarse aggregate

The coarse aggregate for the work should be river gravel or crushed stone. . The coarse aggregate was used in the experimentation were of 20mm and down size aggregate and tested as per IS: 2386-1963 (I, II and III) specifications.

Table 4.4 Physical properties of Coarse aggregate

S. no	Property	Value
1	Type	Crushed
2	Maximum size	20mm
3	Specific gravity	2.66
4	Fineness modulus	8.28

4.2.4 light weight aggregate (pumice)

Pumice is normally used as an aggregate in lightweight building blocks, concrete and assorted building products. Pumice was used in ancient Rome over 2000 years ago and many notable pumice structures are still standing today. In Europe, pumice concrete constitutes about 3% of the total lightweight concrete consumption with 70% of the total consumption in Germany. The use of pumice and perlite as additives was found to provide excellent resistance to freezing and thawing of cement pastes, mortar and concrete. Prefabricated lightweight pumice concrete infill panels were investigated as a retrofit alternative of building frames subjected to quasi-static loading. Investigation on reinforced concretes made with lightweight aggregates (such as pumice and slag) revealed their satisfactory resistance against salt attack/steel corrosion and their suitability of using in load-bearing and enclosure structures. Precast panels made with lightweight pumice concrete were used satisfactorily used in the Rockwood residence in the Hayden Island, Oregon, USA Research has been conducted over the last few years on the use of volcanic ash and pumice in cement and concrete production A large number of natural (such as diatomite, pumice, scoria, sawdust, oil palm shells, and bottom ash) or artificial (such as expanded shale, slag, slate, perlite, and vermiculite) aggregates to manufacture mortar and concrete.

Fig 4.1: Light weight aggregate (pumice)

Table 4.5 Chemical properties of pumice

Chemical compounds	Volcanic pumice mass %
Calcium oxide(Cao)	4.9
Silica (SiO_2)	61.2
Iron Oxide (Fe_2O_3)	7.4
Sulphur trioxide (SO_3)	0.11
Magnesia (MgO)	1.8
Sodium Oxide (Na_2O)	3.9
Potassium Oxide (K_2O)	2.5
Loss on ignition	1.4
Alumina(Al_2O_3)	18.1

Source: Lightweight concrete incorporating pumice based blended cement and aggregate: mechanical and durability characteristics

Table 4.6 Physical properties of light weight aggregate (pumice)

S. no	Property	Value
1	Type	Crushed
2	Maximum size	12.5 mm
3	Specific gravity	1.11

4.2.5 Polypropylene fibres

polypropylene (PP) is a thermoplastic polymer used in a wide variety of applications such as textiles (rope and carpets) , packaging, labeling , stationary , containers , automotive parts and banknotes. Its structure is based on CnH2n monomer. Polypropylene fibres derive from synthetic hydrocarbon polymer through extrusion processes of hot drawing the material through a die .In the production process and based on the properties required , copolymerization among the monomers is necessary for the desired properties to be achieved.It is adopted because of its tensile and flextural strength capability of arresting plastic shrinkage cracks.It has been established that the addition of randomly distributed polypropylene fibres to brittle cement based materials can incresase their fracture toughness,ductility and impact resistance.polypropylene twine is cheap ,abundantly available , and like all manmade fibres of a consistant quality.

Fig 4.2: Sample of polypropylene fibre

4.2.5.1 Specification

Table 4.7 PPF Specification

Specification	Values
Product	Synthetic fibre polypropylene grade
Polymer	100% virgin polypropylene homo – polymer
Construction	Fibrillated multidimensional fibre
Length	Grade 10mm to 20 mm
Specific gravity	0.91
Melting range	162 - 164°c
Reactivity	Inert-not affected by alkali , acid & cement concrete up to 110°c
Reaction with concrete	None, inert material giving only micro reinforcement
Tenacity	4.5 – 5 grams per denier
Strength	500 – 550 Mpa
Diamond length	10-12mm
Elongation	15 -18%
Denier	1000
Thickness	35 – 40 u
Thermal& electrical conductivity	Low
Standard specification	ASTM – 1116 – standard specification for fibre reinforced concrete

Source : ASTM – 1116 – standard specification for fibre reinforced concrete

4.2.6 HYSD bars

HYSD bars are High Yield Strength Deformed bars. As the name implies it has comparatively high strength than mild steel. They are graded as Fe415 , Fe500 i.e. f_y of 415 and 500 N/mm^2 respectively. HYSD bars are preferred when tensile strength reinforcements are high.

4.2.7 water

Water acts lubricant for the fine and coarse aggregate and acts chemical with cement to form the binding paste for the aggregate water is used for curing the concrete after it has cast into the forms .water used for both mixing and curing should be free from contaminants. Potable water is generally considered satisfactory for mixing and curing of concrete .Ordinary tap water used in the preparation of concrete.

5. RESULTS AND DISCUSSION

5.1 GENERAL

In this experimental study, the replacement of coarse with partial replacement of light weight aggregate pumice as a substitute for coarse aggregate in concrete with different polypropylene ratio of 0.5% – 2 %.the test was conducted for 1:1.36:2.15 mix ratio and the results of tests conducted are discussed below.

5.2 COMPRESSIVE STRENGTH

The compressive strength tests were conducted on concrete cube specimens of size 150mmX150mmX150mm.The cubes were tested after curing periods of 7 days, 28 days.

5.2.1 Compressive Strength Of Specimens For 7 Days

The results obtained for cube compressive strengths for the different mixes at 7 days are shown in below table.and are illustrated.

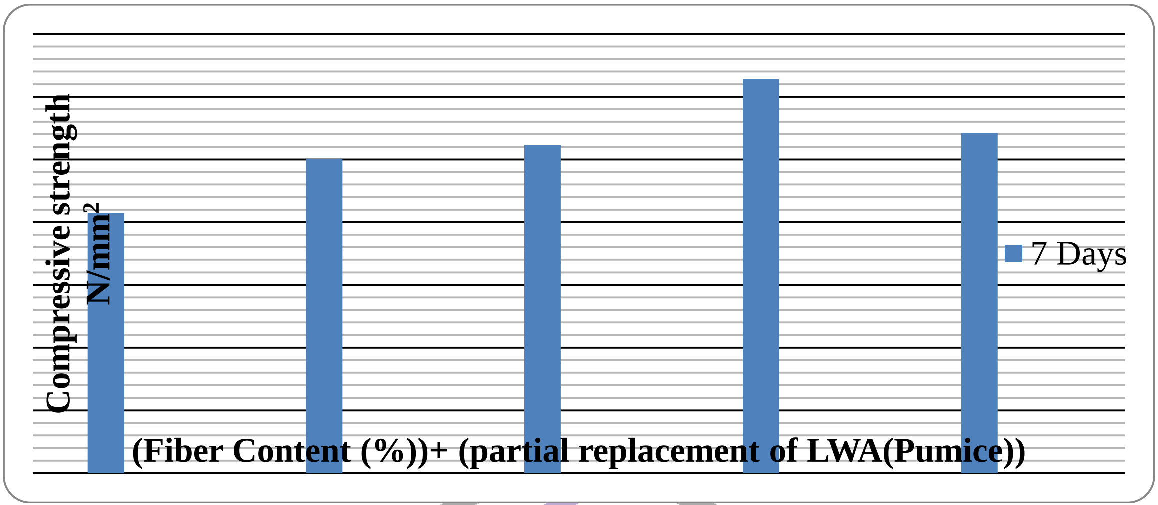


Fig 6.1 Fibre vs compressive strength at 7 days

From the graphical illustration it is clear that the replacement of polypropylene fiber different ratio of 0.5 % ,1%, 1.5 % ,2 % with partial replacement LWA (pumice) in concrete increases compressive strength with a peak increase in samples produced using 1.5% ppf with partial replacement of LWA (Pumice) by coarse aggregate with a value of 31.40 N/mm^2 when compared with nominal concrete strength of 20.74 N/mm^2 at 7 days.

5.2.2 Compressive Strength of Specimens For 28 Days

The results obtained for compressive strengths of cubes for the different mixes at 28 days are shown in below table and are illustrated.

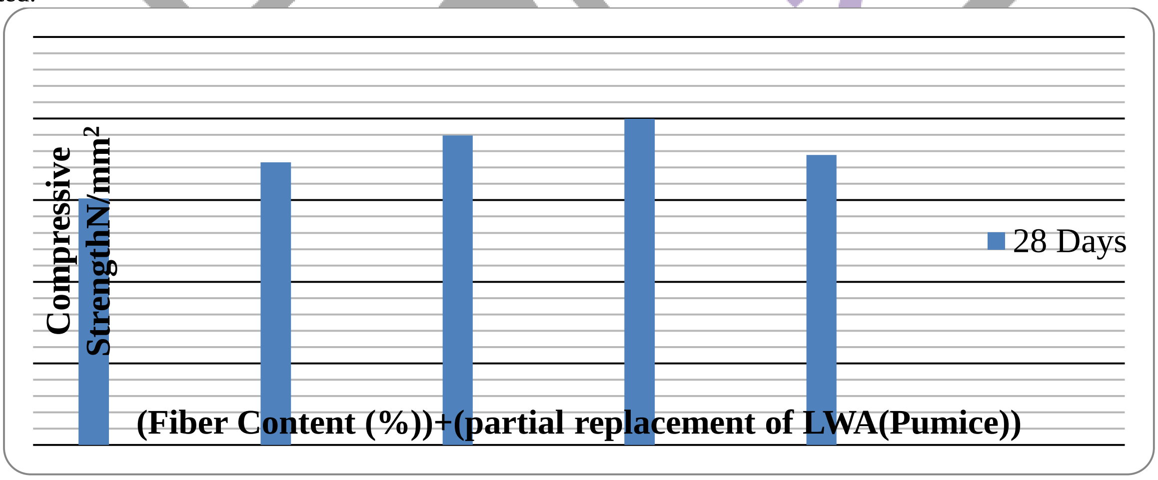


Fig 6.2 Fibre vs compressive strength at 28 days

From the graphical illustration it is clear that the replacement of polypropylene fiber different ratio of 0.5 % ,1%, 1.5 % ,2 % with partial replacement LWA (pumice) in concrete increases compressive strength with a peak increase in samples produced using 1.5% ppf with partial replacement of LWA (Pumice) by coarse aggregate with a value of 39.99 N/mm^2 when compared with nominal concrete strength of 30.22 N/mm^2 at 28 days.

5.2.3 Comparison of Compressive Strength Of Specimens For 7 & 28 Days

The results of variation of compressive strength test of cubes for 7 & 28 days are compared in below tables and the variation of compressive strength of all mixes are are clearly illustrated.

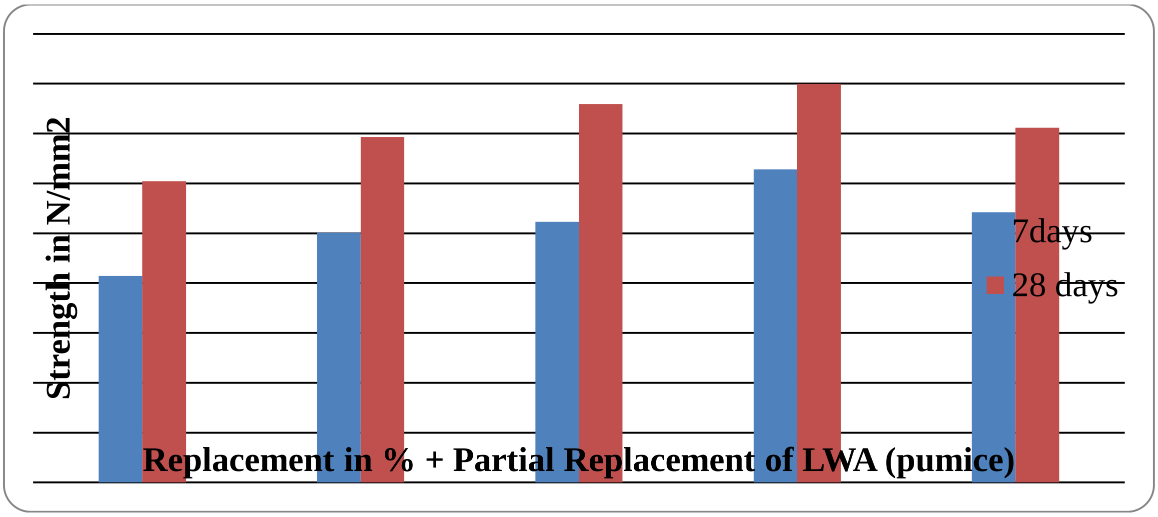


Fig 6.3 Fibre vs compressive strength at 7 & 28 days

Compressive strength test on fibre reinforced with pumice concrete cubes was conducted and the results were compared with controlled concrete. From table 4.3, it can be seen that the 28 days compressive strength of controlled concrete mix M1 is 30.22 N/mm^2 , where as for fiber reinforced with pumice concrete is 35N/mm^2 for 0.5% of polypropylene fiber. Similarly for M2, 28 days of fiber reinforced with pumice concrete is 37.93N/mm^2 for 1%of polypropylene fiber. similarly for M3, 28 days of fiber reinforced with pumice concrete is 39.99N/mm^2 for 1.5% of polypropylene fiber.M4,28 days of fiber reinforced with pumice concrete is 35.57N/mm^2 for 2% polypropylene fiber. It shows that M3 compressive strength of fiber reinforced with pumice concrete was increased compared to controlled concrete.

5.3 SPLIT TENSILE TEST

Split tensile strength of concrete for different percentage of polypropylene fiber with partial replacement of LWA (pumice) by coarse aggregate. The split tensile strength tests were conducted on concrete cylinder specimens of size 150mm dia X 300 mm height. The cylinder were tested after curing periods of 7 days and 28 days.

5.3.1 Split Tensile Strength Test For 7days

The results obtained for spilt tensile strengths of cylinder for the different mixes at 7 days are shown in below table. and are plotted for different variation.

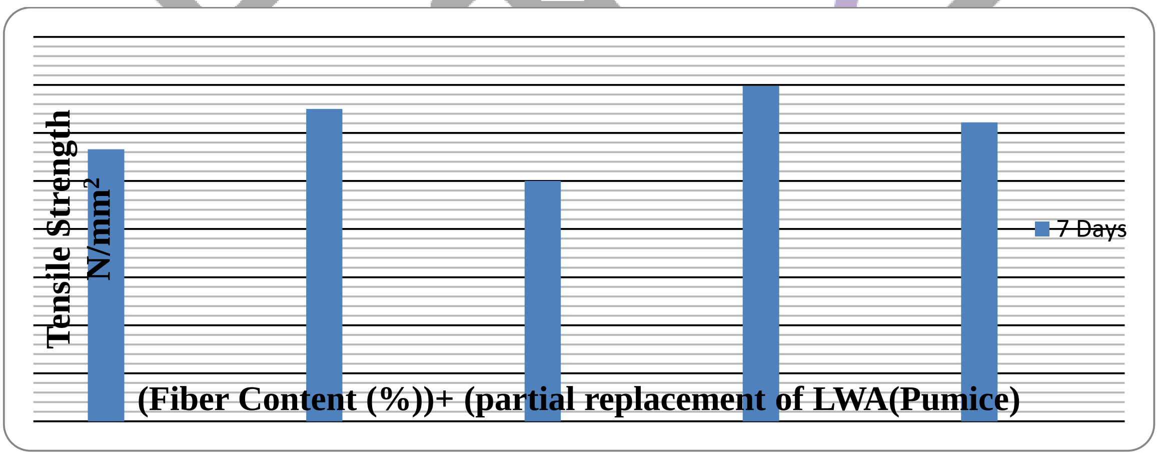


Fig 6.4 Fibre vs split tensile strength at 7 days

From the graphical illustration it is clear that the replacement of polypropylene fiber different ratio of 0.5 % ,1%, 1.5 % ,2 % with partial replacement LWA (pumice) in concrete increases split tensile strength with a peak increase in samples produced using 1.5% ppf with partial replacement of LWA (Pumice) by coarse aggregate with a value of 3.87 N/mm^2 when compared with nominal concrete strength of 2.83 N/mm^2 at 7 days.

5.3.2 Split Tensile Strength Test For cylinder of 28 days

The results obtained for spilt tensile strengths of cylinder for the different mixes at 28 days are shown in below table.and are plotted for different variation

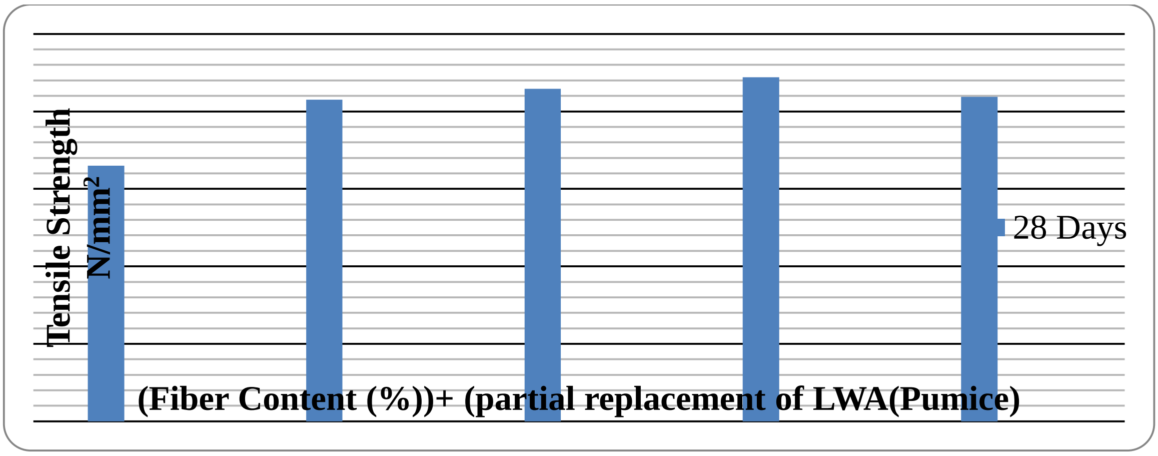


Fig 6.5 Fibre vs split tensile strength at 28 days.

From the graphical illustration it is clear that the replacement of polypropylene fiber different ratio of 0.5 % ,1%, 1.5 % ,2 % with partial replacement LWA (pumice) in concrete increases split tensile strength with a peak increase in samples produced using 1.5% ppf with partial replacement of LWA (Pumice) by coarse aggregate with a value of 4.44 N/mm^2 when compared with nominal concrete strength of 3.30 N/mm^2 at 28 days.

5.3.3 Comparison of Split Tensile Strength of Specimens For 7 & 28 Days

The results of variation of split tensile strength test of cylinder for 7 and 28 days are compared in below tables and the variation of split tensile strength of all mixes are clearly illustrated.

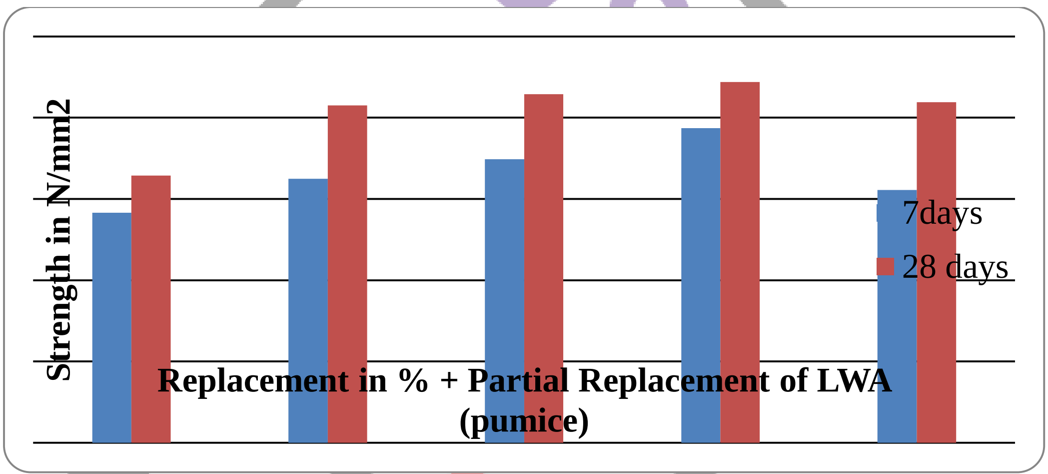


Fig 6.6 Fibre vs split tensile strength at 7 & 28 days

Split tensile test on fibre reinforced with pumice concrete cubes was conducted and the results were compared with controlled concrete. From table 4.6 ,it can be seen that the 28 days split tensile strength of controlled concrete mix M1 is 3.30 N/mm^2 ,where as for fiber reinforced with pumice concrete is 4.15N/mm^2 for 0.5% of polypropylene fiber. Similarly for M2,28 days of fiber reinforced with pumice concrete is 4.29N/mm^2 for 1%of polypropylene fiber. Similarly for M3, 28 days of fiber reinforced with pumice concrete is 4.44N/mm^2 for 1.5% of polypropylene fiber.M4,28 days of fiber reinforced with pumice concrete is 4.19N/mm^2 for 2% polypropylene fiber. It shows that M3 split tensile strength of fiber reinforced with pumice concrete was increased compared to controlled concrete.

5.4 FLEXURAL STRENGTH TEST ON PRISM

Flexural strength of concrete for for different percentage of polypropylene fiber with partial replacement of LWA (pumice) by coarse aggregate. The flexural tests were conducted on prismatic specimens of size 100mmX100mm x500mm. The prism were tested after curing periods of 7 days and 28 days.

5.4.1 Flexural Strength Test For prism of 7 days

The results obtained for flexural strength of prism for the different mixes at 7 days are shown in below table. and are plotted for different variation.

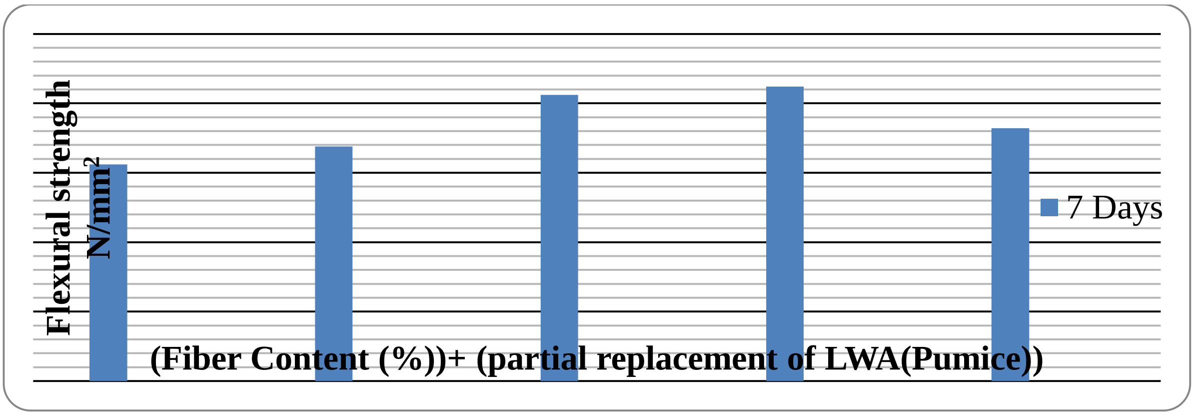


Fig 6.7 Fibre vs flexural strength at 7 days

From the graphical illustration it is clear that the replacement of polypropylene fiber different ratio of 0.5 % ,1%, 1.5 % ,2 % with partial replacement LWA (pumice) in concrete increases flexural strength with a peak increase in samples produced using 1.5% ppf with partial replacement of LWA (Pumice) by coarse aggregate with a value of 2.12 N/mm^2 when compared with nominal concrete strength of 1.56 N/mm^2 at 7 days.

5.4.2 Flexural Strength Test For prism of 28 days

The results obtained for flexural strength of prism for the different mixes at 28 days are shown in below table. and are plotted for different variation

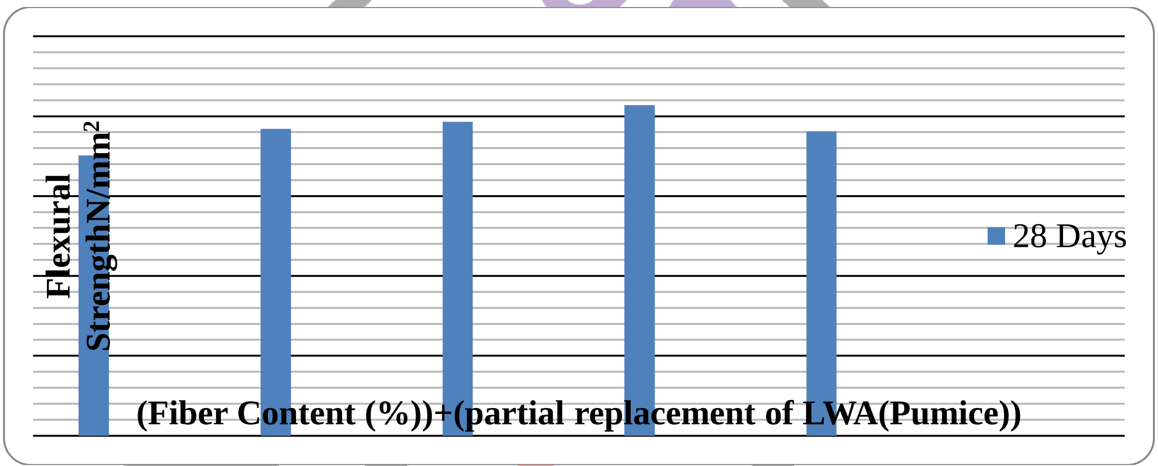


Fig 6.8 Fibre vs flexural strength at 28 days

From the graphical illustration it is clear that the replacement of polypropylene fiber different ratio of 0.5 % ,1%, 1.5 % ,2 % with partial replacement LWA (pumice) in concrete increases flexural strength with a peak increase in samples produced using 1.5% ppf with partial replacement of LWA (Pumice) by coarse aggregate with a value of 4.14 N/mm^2 when compared with nominal concrete strength of 3.51 N/mm^2 at 28 days.

5.4.3 Comparison of flexural strength Of Specimens For 7 & 28 Days

The results of variation of flexural strength test of prism for 7 and 28 days are compared in below tables and the variation of flexural strength of all mixes are clearly illustrated.

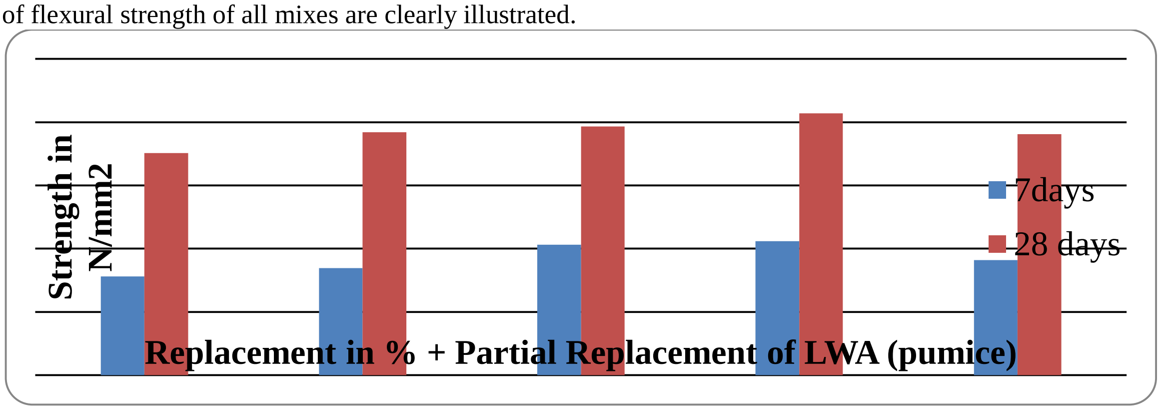


Fig 6.9 Fibre vs flexural strength at 7 & 28 days

Flexural strength test on fibre reinforced with pumice concrete prism was conducted and the results were compared with controlled concrete. From table 4.9, it can be seen that the 28 days flexural strength of controlled concrete mix M1 is 3.51 N/mm^2 , where as for fiber reinforced with pumice concrete is 3.84 N/mm^2 for 0.5% of polypropylene fiber. Similarly for M2,28 days of fiber reinforced with pumice concrete is 3.93 N/mm^2 for 1% of polypropylene fiber. Similarly for M3,28 days of fiber reinforced with pumice concrete is 4.14N/mm^2 for 1.5% of polypropylene fiber.M4,28 days of fiber reinforced with pumice concrete is 3.81 N/mm^2 for 2% polypropylene fiber. It shows that M3 flexural strength of fiber reinforced with pumice concrete was increased compared to controlled concrete.

6. CONCLUSION

The following conclusions could be arrived from this experimental study ,

- In the hardened state of concrete there is an overall increase in strength of concrete both in compressive strength, Flexural strength and split tensile strength for the 1.5% addition polypropylene fibers.
- Polypropylene fibers reduce the water permeability, plastic shrinkage an settlement.
- The compressive strength, split tensile strength & Flexural strength increase with the addition of fiber content as compared with conventional concrete.
- Addition of 1.5% polypropylene fibre with partial replacement of light weight aggregate (pumice) in the RC beams increases the flexural first cracking strength compared to those Conventional RC beams Without addition of polypropylene fiber.
- The first crack can be observed at 16.5 KN .From ASTM C1018 , toughness indices is calculated and the obtained value is $I_5 = 6.69$ and $I_{10} = 19.19$ first crack strength is calculated from the eqn 6.1 and the value obtained is 12.6 N/mm^2 .Residual strength factor $R_{5,10}$ is 250. The modulus of rupture for conventional concrete is 24.75 N/mm^2 .
- The first crack can be observed at 8.4 KN .From ASTM C 1018 , toughness indices is calculated and the obtained value is $I_5 = 7.024$ and $I_{10} = 17.166$ first crack strength is calculated from the eqn 4.1 and the value obtained is 12.6 N/mm^2 .Residual strength factor $R_{5,10}$ is 202.84.The values of 200 correspond to perfectly plastic behavior. The modulus of rupture is 31.2 N/mm^2.

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