**COMPARISON OF HARDENED PROPERTIES OF CONVENTIONAL CONCRETE WITH FIBRE REINFORCED CONCRETE**

**A Thesis Report Submitted to the Andhra University in Partial**

**Fulfillment of the Requirements for the Award of the Degree**

**Bachelor of Engineering**

**CIVIL ENGINEERING**

**Submitted by**

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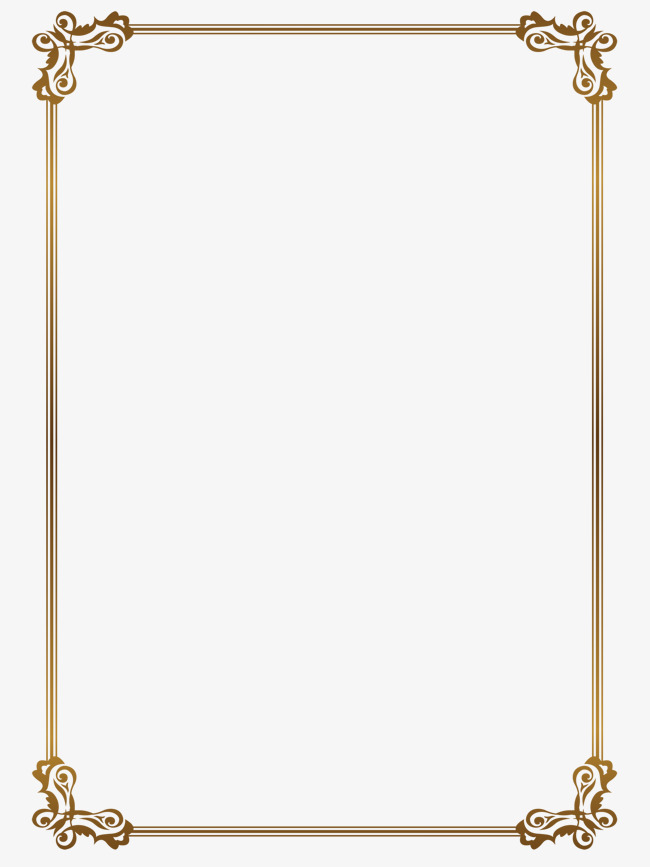
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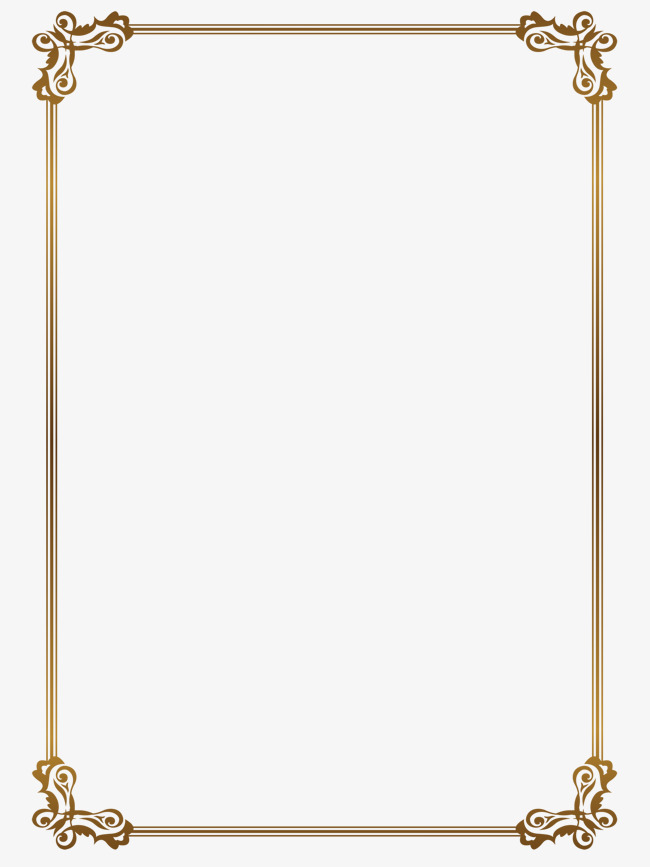
**S.R.K.R. ENGINNERING COLLEGE**

**(Affiliated to Andhra University, Visakhapatnam & Recognised by A.I.C.T.E, Accredited by N.B.A., New Delhi)**

**BHIMAVARAM**

**(2014-2018)**

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**DEPARTMENT OF CIVIL ENGINEERING**

**CERTIFICATE**



***This is to certify that this project work entitled***

**COMPARISON OF HARDENED PROPERTIES OF CONVENTIONAL CONCRETE WITH FIBRE REINFORCED CONCRETE**

***Is the bonafide work of***

***Mr./Ms……………………………………………………………………Regd.No.……………………………of final year Civil Engineering along with his/her batch mates submitted in partial fulfillment of requirements for the award of Civil Engineering by Andhra University during the academic session 2014-2018.***

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**Assistant Professor Professor,**

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**CERTIFICATE OF EXAMINATION**

This is to certify that we had examined the concept and here by accord our approval of it as a project carried out and presented in a manner required for its acceptance on partial fulfillment for the award of degree of **BACHELOR OF ENGINEERING** in **CIVIL ENGINEERING** for which it has been submitted.

This approval does not necessarily endorse or accept every statement made, opinion expressed or conclusions drawn as recorded in the project report. It only signifies the acceptance for the purpose for which it is submitted.

**INTERNAL EXAMINER EXTERNALEXAMINER**

**ACKNOWLEDGEMENTS**

Our most sincere and grateful acknowledgement is due to this Sanctum **SAGI RAMA KRISHNAM RAJU ENGINEERING COLLEGE,** for giving us an opportunity to fulfill our aspirations and for successful completion of Bachelor of Engineering Degree.

We wish to express thanks to various personalities who are responsible for successful completion of this project. Initially we express our deep sense of gratitude to our guide **Sri Chankya Varma,** Assistant Professor, whose valuable guidance and unstinting encouragement enables us to accomplish our project successfully in time. His profound knowledge and willingness have been a constant source of inspiration for us throughout the project work.

We are grateful to **Dr. M. JAGAPATHI RAJU, Ph.D.,** Prof & Head, Civil Engineering Department, for his constant inspiration and suggestions throughout this project work.

We are extremely thankful to **Dr. G.P.S.VARMA,** Principal, S.R.K.R Engineering College, Bhimavaram, for providing necessary facilities to do our project.

Our sincere thanks to **Sri P.Venkateswara rao,** Assistant professor, for his whole hearted commitment and guidance at every stage of our project.

We would like to thank **Sri J.V.Narashimha Raju,** College Engineer, for providing the required fine aggregate and coarse aggregate for the project work.

We are also grateful to the **FACULTY MEMBERS** and **NON-TEACHING STAFF** of the Department of Civil Engineering for their support throughout our project.

Last but not the least, we are very much thankful to our **PARENTS and FRIENDS** whose role is not less than that of anybody.

We wish to thank one and all who supported us directly or indirectly for the completion of this work.

-Project Associates

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**ABSTRACT**

Fibers have played a dominant role for a long time in a variety of applications for their high specific strength and modulus. They can be effectively controlled cracking and use the concrete with crack free and also increase the overall properties like compressive, ductility, flexural, quality of the concrete. Fiber-reinforced concrete (FRC) is concrete containing fibrous material which increases its structural integrity. It contains short discrete fibers that are uniformly distributed and randomly oriented, which are resistant to most chemical attacks. Hence in this project Glass fibers, Polyester fibers and Steel fibers were used which are easily available type of fibers. In this project, the materials such as cement, fly ash, fine aggregate, coarse aggregate and fibers that are going to be used in the specimen preparation were determined and the values have been tabulated. The concrete cubes, cylinders and beams are prepared and the strength properties such as compression strength, split tensile strength and flexural strength are to be determined and compared with the conventional concrete.

In conventional concrete, micro-cracks develop before structure is loaded because of drying shrinkage and other causes of volume change. When the structure is loaded, the micro cracks open up and propagate because of development of such micro-cracks, results in inelastic deformation in concrete. Fiber reinforced concrete (FRC) is cementing concrete reinforced mixture with more or less randomly distributed small fibers. In the FRC, a number of small fibers are dispersed and distributed randomly in the concrete at the time of mixing, and thus improve concrete properties in all directions. The fibers help to transfer load to the internal micro cracks. FRC is cement based composite material that has been developed in recent years. It has been successfully used in construction with its excellent flexural-tensile strength, resistance to spitting, impact resistance and excellent permeability and frost resistance. It is an effective way to increase toughness, shock resistance and resistance to plastic shrinkage cracking of the mortar. These fibers have many benefits. Steel fibers can improve the structural strength to reduce in the heavy steel reinforcement requirement. Durability of the concrete is improved to reduce in the crack widths.

**INTRODUCTION**

**1.1 GENERAL:**

Concrete is a construction material composed of cement as well as other cementitious materials such as fly ash, coarse aggregate, fine aggregate and water. The quality of good and durable concrete does not depend only on the quality of raw materials but also on proper mix-design, placement, vibration and efficient curing.

The concept of using fibers as reinforcement is not new. Fibers have been used as reinforcement since ancient times. In the 1900s, [asbestos](https://en.wikipedia.org/wiki/Asbestos) fibers were used in concrete. In the 1950s, the concept of [composite materials](https://en.wikipedia.org/wiki/Composite_material) came into being and fiber-reinforced concrete was one of the topics of interest. Once the [health risks](https://en.wikipedia.org/wiki/Carcinogen) associated with asbestos were discovered, there was a need to find a replacement for the substance in concrete and other building materials. By the 1960s, [steel](https://en.wikipedia.org/wiki/Steel), [glass](https://en.wikipedia.org/wiki/Glass) ([GFRC](https://en.wikipedia.org/wiki/Glass_Fiber_Reinforced_Concrete_(GFRC))), and synthetic fibers such as [polypropylene](https://en.wikipedia.org/wiki/Polypropylene) fibers were used in concrete. Research into new fiber-reinforced concretes continues today.

**1.2 USAGE OF THE FIBERS:**

Fibers are usually used in concrete to control plastic shrinkage cracking and drying shrinkage cracking. They also lower the permeability of concrete and thus reduce bleeding of water. Some types of fibers produce greater impact, abrasion and shatter resistance in concrete. The promise of thinner and stronger elements reduced weight and controlled cracking by simply adding a small amount of fibers is an attractive feature of fiber-reinforced concrete. The amount of fibers added to a concrete mix is measured as a percentage of the mix. Weight of fiber fraction typically ranges from 0.1 to 3% of cement weight. Fibers include steel fibers, glass fibers, synthetic fibers and natural fibers each of which lends varying properties to the concrete.

A fiber is a small discrete reinforcing material produced from various materials like steel, plastic, glass, carbon and natural materials in various shapes and size. A numerical parameter describing a fiber as its aspect ratio, which is defined as the fiber length, divided by an equivalent fiber diameter [l/d].

The plain concrete fails suddenly when the deflection corresponding to the ultimate flexural strength is exceeded, on the other hand fiber-reinforced concrete continue to sustain considerable loads even at deflections considerably in excess of the fracture deflection of the plain concrete.

**1.3 NEED OF THE PROJECT:**

As the most consumable building material, concrete has been generally used in the world, which has high strength, high elasticity modulus, well plasticity, and workability. The orientation of the modern civil engineering structures is high-rise, high strength, and long design lifetime, which has higher requirements on concrete. In particular, the concrete should have high toughness to prevent sudden brittle failure of the concrete structures. As a result, all kinds of fibers have been added to improve the toughness of the concrete. Researchers are targeting developments of fiber reinforced concrete (FRC) and also working on the mechanism research for special properties, preparation technology, testing methods, modeling, and applications of various fiber reinforced concretes. The development of fiber reinforced concretes will provide better materials for specific projects in civil engineering. An FRC sub-category named High-Performance Fiber Reinforced Concrete claims 500 times more resistance to cracking and 40 percent lighter than traditional concrete. HPFRC claims it can sustain strain-hardening up to several percent strain, resulting in a material [ductility](https://en.wikipedia.org/wiki/Ductility) of at least two orders of magnitude higher when compared to normal concrete or standard fiber-reinforced concrete. HPFRC also claims a unique cracking behavior. When loaded to beyond the elastic range, HPFRC maintains crack width to below 100 µm, even when deformed to several percent tensile strains. Field results with HPFRC and The Michigan Department of Transportation resulted in early-age cracking.

**1.4 OBJECTIVE OF THE PROJECT:**

Your objective should be to make a comparison between fiber reinforced concrete and conventional concrete to see what the performance of each concrete is in both the short term and the long term. Concrete has been around since the Roman times, and it is proved to be a very useful and durable material in many traditional mixes. If you want to change concrete by adding various types of Natural Fibers, those Fibers should impart some beneficial property to the concrete that it already does not have, and that benefit should be very long lasting.

The main purpose of this project is to explore the potential use of FRC for concrete pavement slab replacement. Accordingly, this project has four objectives:

* Develop FRC replacement slab mixtures.
* Evaluate the performance of FRC mixtures particularly on early-age cracking.
* Evaluate the performance of FRC slab using demonstration slabs.
* Develop guidelines for proportioning, mixing, placing, finishing and curing of FRC replacement slab.

**1.5 ADVANTAGES OF FIBRE REINFORCED CONCRETE:**

* Improve structural strength.
* Reduce steel reinforcement requirements.
* Reduce crack widths and control the crack widths tightly, thus improving durability.
* Improve impact– and abrasion–resistance.
* Improve [ductility](https://en.wikipedia.org/wiki/Ductility).
* Improve resistance to explosive [spalling](https://en.wikipedia.org/wiki/Spalling) in case of a severe fire.
* Improve mix cohesion, improving pumpability over long distances.
* Increase resistance to plastic shrinkage during curing.
* Improve freeze-thaw resistance.
* It is used in structures where corrosion is to be avoided at the maximum.
* It is better suited to minimize the cavitation erosion damage in structures where high velocity flows are encountered.
* Fibers reduces internal forces by locking microscopic cracks from forming with in the concrete.
* In earthquake prone areas the use of fiber reinforced concrete would certainly minimize the human causalities.
* Studies have been proven that fibre reinforced concrete is found to improve the following mechanical properties of concrete such as Compression Strength, Toughness, Split Tensile Strength and Impact Resistance.
  1. **DETAILS OF THE SPECIEMENS:**

1. Cubical specimens of size 100mmx100mmx100mm are casted for the determination of compression strength.
2. Cylindrical specimens of size 100mmx150mm are casted for the determination of split tensile strength.
3. Beams of size 500mmx100mmx100mm are casted for the determination of flexural strength.

**LITERATURE REVIEW**

For this purpose, a number of research papers are analyzed. Following are the different research work performed by the researchers.

* In his studies **Pammar P.R**. observed that the specimens made with 0.525% and 0.3% steel and glass fibers gives the more strength compare to other mix proportion and from normal concrete. Increase in percentage of glass reduces the compressive strength. Workability of normal concrete is more compare to fiber reinforced concrete; it was observed that percentage of steel increase means there is reduced in workability. From acid test it was observed that the specimens exposed to acid shows lesser compressive strength compare to unexposed to acid. The specimens made with 0.525% and 0.3% steel and glass fiber shows the better compressive strength compare to other specimens. And loss of weight was more in increased percentages of glass fiber.
* **Patil T.R.** and **Burile A.N.** in their studies concluded that the addition of steel fibers at 0.5 % by volume of concrete reduces the cracks under different loading conditions. The brittleness of concrete can also be improved by addition steel fibers than glass fibers. Since concrete is very weak in tension, the steel fibers are beneficial in axial-tension to increase tensile strength. Also, the ratio of compressive strength of cylinders to the compressive strength of cube was found to be nearly 3:4. Workability of concrete affected by addition of fibers. Addition of Steel fiber reduces workability of concrete in comparison to other fibers for different volume fraction. It was found that while using glass fiber in Split Tensile test the crack width goes on reducing with increasing of fiber dose.
* **Prasad M.C.** in their studies found that the concrete mixed with dual fiber would also have much more life in comparison with the conventional concrete. The fibrous concrete is found to have maximum ultimate load carrying capacity as conventional concrete. The fibrous concrete is stiffer than the conventional concrete in appreciable way. For the nominal M25 mix with a water cement ratio of 0.5 used in the present investigation, the workability of concrete is only marginally affected even with a total fiber content of 1.0 percent by volume. The compressive strength of dual fiber concrete is found to be maximum at 1.0% total fiber content of steel at 28 days compared to plain concrete. There is substantial increase in the compressive strength for mixed fiber combination. As the percentage of steel fiber is reduced and glass fiber is increased, the compressive strength is getting reduced compared to that of 100% steel fiber in the matrix. Steel fiber of 1 mm diameter and length of 50 mm having an aspect ratio of 50 can be satisfactorily mixed along with glass fiber having an aspect ratio of nearly 800 to increase the strength and other characteristics. The split tensile strength of dual fiber concrete is found to be maximum at 1.0 % total steel fiber content at 28 days compared to plain cement concrete.
* **Ragi S** found that the increasing percentage of compressive strength of hooked end steel fiber reinforced concrete cubes when compared to the conventional concrete cubes at 28 days is 7.3%. And the increasing percentage of compressive strength of crimped steel fiber reinforced concrete cubes when compared to the conventional concrete cubes at 28 days is 6.08%. Also, the increasing percentage of split tensile strength of hooked end steel fiber reinforced concrete cylinders when compared to the conventional concrete cylinders at 28 days is 4.54%.
* **Khan.Y** found that the compressive strength of fiber reinforced concrete composite with various mix designation found higher as compared to normal conventional concrete for 7 and 28 days of curing and the split Tensile strength of fiber reinforced concrete composite with various mix designation showed higher strength as compared to normal conventional concrete. Also, The Compressive strength of fiber reinforced concrete composite for mix designation with (steel 2% & glass 2.5%) showed higher strength compared to other mix designation and conventional concrete.
* **Kumar J.D.** in their studies found that the addition of glass fibers at 0.5%, 1%, 2% and 3% of cement reduces the cracks under different loading conditions. It has been observed that the workability of concrete increases at 1% with the addition of glass fiber. The increase in compressive strength, flexural strength, split tensile strength for M-20 grade of concrete at 7 and 28 days are observed to be more at 1%. We can likewise utilize the waste product of glass as fiber.

**MATERIALS**

**3.1 CEMENT:**

Ordinary Portland Cement is the general type of cement in use around the world, it is the basic key ingredient for making concrete, mortar. It is made by inter-grinding of argillaceous and calcareous materials. The cement used was Ordinary Portland cement (53 Grade) with a specific gravity of 3.15. Initial and final setting time of the cement was 30 min and 600 min, respectively. Ordinary Portland cement of 53 grade was used, conforming I.S.-12269-1987.

* 1. **FLY ASH:**

Fly ash is finely divided residue resulting from the combustion of powdered coal and transported by the flue gases and collected by electrostatic precipitator. In U.K. it is referred as pulverized fuel ash. Fly ash is the most widely used pozzolanic material all over the world. One of the well-known engineer E.A.Abdun-Nur has said the following in 1984.

“In the real world of modern concrete, fly ash is as essential an ingredient of the mixture as are Portland cement, aggregate, water and chemical admixtures. In most concretes, I use it in larger amounts (by volume) than Portland cement, and therefore it is not an admixture i.e., an addition to the mixture. Concrete without fly ash and chemical admixtures should only be found in museum showcases”.

In the recent time, the importance and use of fly ash in concrete has grown so much that it has almost become a common ingredient in concrete, particularly for making high strength and high-performance concrete. Extensive research has bee done all over the world on the benefits that could be accrued in the utilization of fly ash as a supplementary cementitious material. High volume fly ash concrete is a subject of interest all over the world.

The use of fly ash as concrete admixture not only extends technical advantages to the properties of concrete but also contributes to the environmental pollution control. In India alone, we produce more than about 100 million tons of fly ash as per year, the disposal of which has become a serious environmental problem.

According to the type of coal used for combustion, ASTM C 618 broadly classified fly ash into two classes.

**Class F:** Fly ash normally produced by burning anthracite or bituminous coal, usually has less than 5% CaO. Class F fly ash has pozzolanic properties only.

**Class C:** Fly ash normally produced by burning lignite or sub bituminous coal, some class C fly ash may have CaO content in excess of 10%. In addition to pozzolanic properties Class C fly ash also possesses cementitious properties.

It is necessary to understand the characteristics of fly ash before we consider its application as the characteristics govern its suitability for various end uses and its characteristics must be thoroughly understood to get full beneficial potentials. Generally, we used Class F in this Fiber reinforced concrete.

Fly ash, when used in concrete, contributes to the strength of concrete due to its pozzolanic reactivity. However, since the pozzolanic reaction proceeds slowly, the initial strength of fly ash concrete tends to be lower than that of concrete without fly ash. Due to continued pozzolanic reactivity concrete develops greater strength at later age, which may exceed that of the concrete without fly ash. The pozzolanic reaction also contributes to making the texture of concrete dense, resulting in decrease of water permeability and gas permeability. It should be noted that since pozzolanic reaction can only proceed in the presence of water enough moisture should be available for long time. Therefore, fly ash concrete should be cured for longer period. In this sense, fly ash concrete used in under water structures such as dams will derive full benefits of attaining improved long-term strength and water-tightness.

**Physical Properties of Fly Ash**

|  |  |  |
| --- | --- | --- |
| **S.No.** | **Properties** | **Range** |
| 1 | Colour | Whitish grey |
| 2 | Bulk density (Kg/m3) | 1180 |
| 3 | Specific gravity | 2.18 |
| 4 | Percentage passing 75-micron I.S. sieve | 71.4 - 95.90 |
| 5 | Percentage passing 45-micron I.S. sieve | 45.0 - 88.80 |
| 6 | Fineness (cm2/gm) | 3300 - 6250 |
| 7 | Lime reactivity (Kg/cm2) | 50 - 62.40 |

**3.3 FINE AGGREGATES:**

Good river bank sand in absence of any earthy matter and organic matter. Particles are nearly angular in shape passing 250 microns and retaining 150 microns standard sieve. Sample is washed in water to get free from earthy and other organic content and dried over a period of 48 hours of sunlight. Locally available sand, confirming to zone II with specific gravity 2.45, water absorption 2% and fineness modulus 3.18, conforming to I.S. – 383-1970.

|  |  |  |
| --- | --- | --- |
| **S.No.** | **Properties** | **Value** |
| 1 | Specific gravity | 2.64 |
| 2 | Fineness modulus | 2.75 |
| 3 | Bulk density  Loose  Compacted | 16.20 KN/m3  17.20 KN/m3 |
| 4 | Grading | Zone-II |

**Physical Properties of Fine Aggregates**

**3.4 COARSE AGGREGATES:**

Maximum size of the coarse aggregate should be restricted to 10mm, to avoid appreciable reduction in strength of the composite. Fibers also in effect, act as aggregate. Although they have a simple geometry, their influence on the properties of fresh concrete is complex. The inter-particle friction between fibers and between fibers and aggregates controls the orientation and distribution of the fibers and consequently the properties of the composite. Friction reducing admixtures and admixtures that improve the cohesiveness of the mix can significantly improve the mix. Crushed granite stones of maximum 20 mm size having specific gravity of 2.67, fineness modulus of 7.10, conforming to IS 383-1970.

**Physical Properties of Coarse Aggregates**

|  |  |  |
| --- | --- | --- |
| **S. No.** | **Properties** | **Value** |
| 1 | Specific gravity | 2.68 |
| 2 | Fineness modulus | 7.17 |
| 3 | Nominal maximum size | 20mm |
| 4 | Bulk density  Loose state  Dense state | 1400 (Kg/m3)  1580 (Kg/m3) |

**3.5 WATER:**

The water to be used for the mix should be clean and of good quality. Potable water was used for the experimentation.

**3.6 FIBERS:**

In this work, effects on strength of concrete with steel fibers, polyester and alkali resistance glass fibers at low volume fraction were studied.

**3.6.1 POLYESTER FIBERS:**

Polyester is also one of the cheapest and abundantly available polymers. Polyester fibers are resistant to most chemical attacks and increase the flexural strength, compression strength and workability will also good as compare to polypropylene fiber. Though not as widely used as polypropylene fibers, polyester fibers are offered by several manufacturers. The fiber bundles come only in monofilament form in lengths from 0.75 to 2 inches.

**3.6.1.1 CHARACTERISTICS PROPERTIES OF POLYESTER FIBERS:**

* Strong
* Resistant to stretching and shrinking
* Resistance to most chemicals
* Quick drying
* Crisp and resilient when wet or dry
* Wrinkle resistance
* Mildew resistance
* Abrasion resistance
* Retains heat-set pleats and crease
* Easily washed
  + 1. **STEEL FIBERS:**

Steel fibers are often used to replace the nominal conventional steel fabric in ground bearing slabs. Steel fibers are increasingly being used in suspended ground floor slabs on piles and in many cases of the reinforcement. There may also be health and safety benefits resulting from the reduced handling of reinforcement. In addition, problems caused by the misplacement of conventional steel in the depth of the slab are avoided. Steel fibers diameter ranges from 0.25 to 0.75mm. The steel fibers, which are uniformly distributed in the cementations mix. This mix, have various volume fractions, geometries, orientations and material properties. It has been shown in the research that fibers with low volume fractions (<1%), in fiber reinforced concrete, have an insignificant effect on both the compressive and tensile strength.

* + - 1. **CHARACTERISTIC PROPERTIES OF STEEL FIBERS:**
* High fatigue strength resistance to impact, blast and shock loads.
* Shrinkage control of concrete
* High tensile strength
* High flexural strength and shear
* Erosion resistance
* Abrasion resistance
* Earthquake resistance
* Temperature resistance

* + 1. **GLASS FIBERS:**

Glass fiber-reinforced concrete consists of the high-strength, alkali-resistant glass fiber embedded in a concrete matrix.  In this form, both fibers and matrix retain their physical and chemical identities. In general, fibers are the principal load-carrying members, while the surrounding matrix keeps them in the desired locations and orientation, acting as load transfer medium between the fibers and protecting them from environmental damage. Glass fibers diameter ranges from 0.005 to 0.015mm. Inclusion of these fibers in these composite results in improved tensile strength and impact strength of the material. Glass fibers has been used for a period of 30 years in several construction elements but at that time it was not so popular, mainly in non-structural ones, like facing panels, used in piping for sanitation network systems, decorative non-recoverable formwork, and other products. At the beginning age of the Glass fibers development, one of the most considerable problems was the durability of the glass fiber, which becomes more brittle with time, due to the alkalinity of the cement mortar. After some research, significant improvement has been made, and presently, the problem is practically solved with the new types of alkali-resistant (AR resistance) glass fibers and with mortar additives that prevent the processes that lead to the embrittlement of Glass fibers.

* + - 1. **CHARACTERISTICS PROPERTIES OF GLASS FIBERS:**
* High tensile strength
* Fire resistant
* Dimensional stability
* High heat resistance
* Good thermal conductivity
* Good chemical resistance
* Durability
* Incombustibility
* Corrosion resistance
* Sound insulation
  + 1. **ASPECT RATIO OF FIBER:**

The strength of the composite largely depends on the quantity of fibers used in it. Use of higher percentage of fiber is likely to cause segregation and harshness of concrete and mortar.

Another important factor which influences the properties and behavior of the composite is the aspect ratio of the fiber. It has been reported that up to aspect ratio of 75, increase in the aspect ratio ncreases the ultimate strength of the concrete linearly. Beyond 75, relative strength and toughness is reduced.

**Effects of Aspect Ratio on Strength and Toughness**

|  |  |  |  |
| --- | --- | --- | --- |
| **Type of Concrete** | **Aspect Ratio** | **Relative Strength** | **Relative Toughness** |
| Plain Concrete with  Randomly dispersed fibres | 0 | 1.00 | 1.0 |
| 25 | 1.50 | 2.0 |
| 50 | 1.60 | 8.0 |
| 75 | 1.70 | 10.5 |
| 100 | 1.50 | 8.5 |
|  |  |  |  |

**EXPERIMENTAL INVESTIGATION**

**4.1 MIX PROPORTION:**

|  |  |  |
| --- | --- | --- |
| **Material** | **Quantity** | **Proportion** |
| Cement | 372 Kg/m3 | 1 |
| Fly ash | 41.33 Kg/m3 | 0.1 |
| Sand | 823.42 Kg/m3 | 1.9 |
| Coarse aggregate (20mm) | 1048 Kg/m3 | 2.5 |
| Water | 186 Kg/m3 | 0.45 |

* 1. **CASTING OF SPECIMENS:**

After the sample has been remixed, immediately fill the moulds and compact the concrete, either by hand or by vibration. Any air trapped in the concrete will reduce the strength of the specimens. Hence, the specimens must be fully compacted. However, care must also be taken not to over compact the concrete as this may cause segregation of the aggregates and cement paste in the mix. This may also reduce the final compressive strength, split tensile strength and flexural strength.These moulds should be filled in three approximately equal layers. During the compaction of each layer by means of a vibrating table or hammer, the mould should preferably be placed on a level piece of timber or table. The concrete should be vibrated by holding the foot of the hammer against a piece of timber placed over but not completely covering the top of the mould. The applied vibration by either the vibrating hammer or table should be of the minimum duration necessary to achieve full compaction of the concrete. Vibration should cease as soon as the surface of the concrete becomes relatively smooth and air bubbles cease to appear.

While finishing off the surface of the concrete, if the mould is too full, the excess concrete should not be removed by scraping off the top surface as this takes off the cement paste that has come to the top and leaves the concrete short of cement. The correct way is to use a corner of the trowel and dig out a fair sample of the concrete as a whole, then finish the surface by troweling. Once a specimen has been compacted, it should not be left standing on the same bench as another specimen that is being compacted. If this is done, some vibration will be passed on to the first specimen and it will be more compacted than the other. In extreme cases some re-arranging of the particles may result and segregation will occur. Once a specimen has been compacted, it should not be left standing on the same bench as another specimen that is being compacted. If this is done, some vibration will be passed on to the first specimen and it will be more compacted than the other. In extreme cases some re-arranging of the particles may result and segregation will occur.

* 1. **CURING:**

Curing is maintaining of an adequate moisture content and temperature in concrete at early ages so that it can develop properties the mixture was designed to achieve. Curing begins immediately after placement and finishing so that the concrete may develop the desired strength and durability. Without an adequate supply of moisture, the cementitious materials in concrete cannot react to form a quality product. Drying may remove the water needed for this chemical reaction called hydration and the concrete will not achieve its potential properties.

Temperature is an important factor in proper curing, since the rate of hydration, and therefore, strength development, is faster at higher temperatures. Generally concrete temperature has to be maintained above 10ᵒC for an adequate rate of strength development. Further, a uniform temperature should be maintained throughout concrete section while it is gaining strength to avoid thermal cracking. For exposed concrete, relative humidity and wind conditions are also important, they contribute to rate of moisture loss from the concrete and could result in cracking, poor surface quality and durability. Protective measures to control evaporation of moisture from concrete surfaces before it sets are essential to prevent plastic shrinkage cracking.

* 1. **TESTS:**
     1. **SLUMP CONE TEST:**

Slump is a [measurement of concrete's workability](https://www.aboutcivil.org/methods-workability-measurement), or fluidity. It's an indirect measurement of concrete consistency or stiffness. A slump test is a method used to determine the consistency of concrete. The consistency, or stiffness, indicates how much water has been used in the mix. The stiffness of the concrete mix should be matched to the requirements for the finished product quality. The concrete slump test is used for the measurement of a [property of fresh concrete](https://www.aboutcivil.org/Properties-of-concrete-factors-affecting-them.html). The test is an empirical test that measures the workability of fresh concrete. More specifically, it measures consistency between batches. The test is popular due to the simplicity of apparatus used and simple procedure. The slump test result is a measure of the behavior of a compacted inverted cone of concrete under the action of gravity. It measures the consistency or the wetness of concrete.

**Procedure for Slump Cone Test**:

1. The mold for the slump test is a frustum of a cone, 300 mm (12 in) of height. The base is 200 mm (8in) in diameter and it has a smaller opening at the top of 100 mm (4 in).
2. The base is placed on a smooth surface and the container is filled with concrete in three layers, whose workability is to be tested .
3. Each layer is temped 25 times with a standard 16 mm (5/8 in) diameter steel rod, rounded at the end.
4. When the mold is completely filled with concrete, the top surface is struck off (leveled with mould top opening) by means of screening and rolling motion of the temping rod.
5. The mould must be firmly held against its base during the entire operation so that it could not move due to the pouring of concrete and this can be done by means of handles or foot - rests brazed to the mold.
6. Immediately after filling is completed and the concrete is leveled, the cone is slowly and carefully lifted vertically, an unsupported concrete will now slump.
7. The decrease in the height of the center of the slumped concrete is called slump.
8. The slump is measured by placing the cone just besides the slump concrete and the temping rod is placed over the cone so that it should also come over the area of slumped concrete.
9. The decrease in height of concrete to that of mold is noted with scale.

**4.4.2 COMPRESSION TEST:**

The strength of concrete is usually defined and determined by the crushing strength of 100mm x 100mmx100mm, at an age of 7, 14 and 28days. Steel mould made of cast iron having dimension 100mmx 100mmx100mm used for casting of concrete cubes filled with steel fibers and alkali resistance glass fibers 0.5% and 1% by weight of cement.

For cube test two types of specimens either cubes of 15cm X 15cm X 15cm or 10cm X 10cm x 10cm depending upon the size of aggregate are used. For most of the works cubical moulds of size 15cm x 15cm x 15cm are commonly used. This concrete is poured in the mould and tempered properly so as not to have any voids. After 24 hours these moulds are removed and test specimens are put in water for curing. The top surface of these specimen should be made even and smooth. This is done by putting cement paste and spreading smoothly on whole area of specimen. These specimens are tested by compression testing machine after 7 days curing, 14 days curing and 28 days curing. Load should be applied gradually at the rate of 140 kg/cm2 per minute till the Specimens fails. Load at the failure divided by area of specimen gives the compressive strength of concrete.

**Procedure for Compression Test**:

1. Remove the specimen from water after specified curing time and wipe out excess water from the surface.
2. Take the dimension of the specimen to the nearest 0.2m
3. Clean the bearing surface of the testing machine
4. Place the specimen in the machine in such a manner that the load shall be applied to the opposite sides of the cube cast.
5. Align the specimen centrally on the base plate of the machine.
6. Rotate the movable portion gently by hand so that it touches the top surface of the specimen.
7. Apply the load gradually without shock and continuously at the rate of 140 kg/cm2/minute till the specimen fails
8. Record the maximum load and note any unusual features in the type of failure.
9. Note down the breaking load (P).
   * 1. **SPLIT TENSILE TEST:**

The tensile strength of concrete is one of the basic and important properties. Splitting tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete. The concrete is very weak in tension due to its brittle nature and is not expected to resist the direct tension. The concrete develops cracks when subjected to tensile forces. Thus, it is necessary to determine the tensile strength of concrete to determine the load at which the concrete members may crack. For tensile strength test, cylindrical specimens of dimension 100 mm diameter and 200 mm length were cast. The specimens were demoulded after 24 hours of casting and were transferred to curing tank where in they were allowed to cure for 7,14 and 28 days. In each category, three cylinders were tested and their average value was reported. The split tension test was conducted using compression machine having 2000kN capacity.

**Procedure of Split Tensile Test:**

1. Take the wet specimen from water after 7 days of curing
2. Wipe out water from the surface of specimen
3. Draw diametrical lines on the two ends of the specimen to ensure that they are on the same axial place.
4. Note the weight and dimension of the specimen.
5. Set the compression testing machine for the required range.
6. Keep are plywood strip on the lower plate and place the specimen.
7. Align the specimen so that the lines marked on the ends are vertical and centered over the bottom plate.
8. Place the other plywood strip above the specimen.
9. Bring down the upper plate to touch the plywood strip.
10. Apply the load continuously without shock at a rate of approximately 14-21kg/cm2/minute (Which corresponds to a total load of 9900kg/minute to 14850kg/minute)
11. Note down the breaking load(P)

**4.4.4 FLEXURAL STRENGTH TEST:**

Flexural test evaluates the tensile strength of concrete indirectly. It tests the ability of unreinforced concrete beam or slab to withstand failure in bending. Flexural test on concrete based on the ASTM standards are explained. Differences if present in specification or any other aspects of flexural test on concrete between ASTM standard, Indian standard, and British standard are specified. The flexural test on concrete can be conducted using either thr point load test or center point load test in universal testing machine (UTM). The dimension of the beam 500mmx100mmx100mm. The test should be conducted on the specimen immediately after taken out of the curing condition so as to prevent surface drying which decline flexural strength. Center the loading system in relation to the applied force.

**Procedure of Flexural Strength Test:**

1. The test should be conducted on the specimen immediately after taken out of the curing condition so as to prevent surface drying which decline flexural strength.
2. Place the specimen on the loading points. The hand finished surface of the specimen should not be in contact with loading points. This will ensure an acceptable contact between the specimen and loading points.
3. Center the loading system in relation to the applied force.
4. Bring the block applying force in contact with the specimen surface at the loading points.
5. Applying loads between 2 to 6 percent of the computed ultimate load.
6. Employing 0.10 mm and 0.38 mm leaf-type feeler gages, specify whether any space between the specimen and the load-applying or support blocks is greater or less than each of the gages over a length of 25 mm or more.
7. Eliminate any gap greater than 0.10mm using leather shims (6.4mm thick and 25 to 50mm long) and it should extend the full width of the specimen.
8. Capping or grinding should be considered to remove gaps in excess of 0.38mm.
9. Load the specimen continuously without shock till the point of failure at a constant rate (Indian standard specified loading rate of 400 Kg/min for 150mm specimen and 180kg/min for 100mm specimen, stress increase rate 0.06+/-0.04N/mm2.s according to British standard).
10. Note down the breaking load (P).

**RESULTS AND DISCUSSIONS**

**5.1 COMPARISSON:**

**5.1.1 Compressive Strength Results:**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **S. No.** | **Age**  **(days)** | **CC**  **(MPa)** | **SF**  **(MPa)** | | **GF**  **(MPa)** | | **PF**  **(MPa)** | |
|  |  |  | **0.5 %** | **1 %** | **0.5 %** | **1 %** | **0.5 %** | **1 %** |
| 1 | 7 | 20.16 | 23.5 | 30.16 | 29.5 | 16.33 | 28.4 |  |
| 2 | 14 | 26.16 | 30.83 | 35.13 | 33 | 25.33 | 37 |  |
| 3 | 28 | 38.83 | 41.83 | 52 | 42.6 | 29.83 | 43.83 |  |

**5.1.2 Split Tensile Strength Results:**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **S. No.** | **Age**  **(days)** | **CC**  **(MPa)** | **SF**  **(MPa)** | | **GF**  **(MPa)** | | **PF**  **(MPa)** | |
|  |  |  | **0.5 %** | **1 %** | **0.5 %** | **1 %** | **0.5 %** | **1 %** |
| 1 | 7 | 1.37 | 1.88 | 2.92 | 2.45 | 2.06 | 2.37 |  |
| 2 | 14 | 1.88 | 2.48 | 3.46 | 3.14 | 2.69 | 3.42 |  |
| 3 | 28 | 3.39 | 3.71 | 3.75 | 4.38 | 3.23 | 4.34 |  |

**5.1.3 Flexural Strength Results**:

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **S. No.** | **Age**  **(days)** | **CC**  **(MPa)** | **SF**  **(MPa)** | | **GF**  **(MPa)** | | **PF**  **(MPa)** | |
|  |  |  | **0.5 %** | **1 %** | **0.5 %** | **1 %** | **0.5 %** | **1 %** |
| 1 | 7 | 2.64 | 3.35 | 4.38 | 5.74 | 4.8 | 3.95 |  |
| 2 | 14 | 3.06 | 4.61 | 5.37 | 6.24 | 4.84 | 4.9 |  |
| 3 | 28 | 4.86 | 5.71 | 5.79 | 10.8 | 4.83 | 6.23 |  |

**SCOPE OF WORK**

Fiber reinforced concrete in addition with plain concrete which is brittle material in nature and the inclusion of fibers may improve the mechanical properties of concrete and the hybridization can compensate the disadvantages. Concrete has high compressive strength, but it is remarkably weak in tension and is usually reinforced with materials that are strong in tension (often steel). Reinforcement solutions to plain concrete in the form of steel bars have existed and been studied for a long time now. However, a whole new spectrum of possibilities are open with the use of steel, glass, polyester, natural (coir) and some other fibers which have been found to improve the ductility of plain concrete and leads to the various specific applications of structural concrete.

1. The effects of the fiber dosage on fatigue characteristics, impact strength, shear strength, shrinkage, creep, thermal properties and durability require further investigation.
2. Further research to study the influence of fiber contents higher than 30 kg/m3 is required.
3. Future investigations on slabs should consider the dimension of the slabs and comer and edge conditions. Larger slabs dimensions are recommended.
4. Further investigations are required by using larger slabs to further assess.
5. The study can be done using different types of fibers such as polyester, carbon, glass, polyester fibers in ternary blended combinations when subjected to different sustained elevated temperatures.
6. Effect of sudden cooling, gradual cooling and intermittent cooling on the properties of steel fiber reinforced ternary blended concrete when subjected to sustained elevated temperatures.
7. Effect of different aspect ratios and different volume fractions on the properties of steel fiber reinforced ternary blended concrete when subjected to sustained elevated temperatures
8. The effect of different aggregate types on the properties of steel fiber reinforced ternary blended concrete when subjected to sustained elevated temperatures.

**CONCLUSION**

In conclusion, I have found that fiber reinforced concrete, while a viable solution by itself, seems to be a more effective solution as a part of a reinforcing system within the concrete. The system of both steel rebar and synthetic fibers would combine the benefits of both reinforcement types to create a strong yet durable reinforced concrete. The practical application of a strong and durable reinforced concrete would satisfy the structural engineer’s design, architects aesthetic requirements, and contractors ease of use.

1. The use of glass and steel fibres in replacing cement definitely increases the fundamental properties of concrete but could only be done up to a certain percentage after which the concrete starts to lose strength.
2. Use of fibres reduce workability of concrete and hence could only be used in little amount.
3. Improvement in the surface integrity and reduction in bleeding is observed in most of the cases when using fibre reinforced concrete.
4. The brittleness of concrete could be improved with addition steel fibres and not so much with glass fibres.
5. Fibre addition improves ductility of concrete and its post-cracking load-carrying capacity.
6. Use of fibre produces more closely spaced cracks and reduces crack width. Fibre bridge cracks to resist deformation.
7. FRC controls cracking and deformation under impact load much better than plain concrete and increased the impact strength 25 times.

From the discussions it has been proved that the fibre reinforced concrete not only has capability to reduce the cracks but also has capability of inducing additional compressive strength to the concrete. Fibre reinforced concrete utilization in pavements reduces the maintenance cost by reducing the overall lifecycle cost though it has high initial cost. The inclusion of fibres is more advantage in case of pavements by reducing the crack formation and also giving additional early compressive strength to the concrete.

The concrete with Polyester fibre is most efficient in inducing the additional strength to the concrete when compared to other fibres. The concrete with Polyester fibre is most economical when compared to other fibres. So we conclude that the concrete with Polyester fibre is the best fibre for Pavement Quality Concrete when compared to Control plain sample and Polypropylene fibre.

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