International Journal of Innovative Research in Engineering and Management (IJIREM)
ISSN (Online): 2350-0557, Volume-11, Issue-5, October 2024
https://doi.org/10.55524/ijirem.2024.11.5.7
Article ID IJIR3022, Pages 48-58
www.ijirem.org

Utilization of Electronic Waste and Textile Fibers as Reinforcements in Concrete Pavement

Mohammad Aejaz Mir[1], and Er. Ashish kumar[2]

[1] M. Tech Scholar, Department of Civil Engineering, RIMT University, Mandi Gobindgarh, Punjab, India
[2] Assistant Professor, Department of Civil Engineering, RIMT University, Mandi Gobindgarh, Punjab, India

Correspondence should be addressed to Mohammad aejaz mir; aejazmir278@gmail.com

Received: 2 September 2024 Revised: 16 September 2024 Accepted: 30 September 2024

ABSTRACT- Throughout the past couple of decades, this is an increasing concern regarding the disposal of textile scraps. The textile market is influenced by both population growth, capital, and style. The fast fashion cycle in the apparel industry has resulted in top levels of utilization while also generating waste. The textile industry's fast fashion cycle promotes excessive consumption and waste. The textile and garment industry is notoriously polluting, so this could hurt the environment. Textile manufacturing requires a significant amount of water due to its chemical nature. Waste from textile production primarily consists of wastewater and fiber waste. Unwanted clothing in the textile production chain led to the majority of fiber waste. This paper investigates how adding textile and electronic waste to concrete affects its properties. Electronic waste and textile fibers were cut into 20mm x 8mm pieces and used at a 1.5% volume ratio. The concrete grades used were M30, M35, and M40. The concrete combined plan is based on IRC 44:2008 standards. Current evaluations involving the durability properties of fiber-reinforced concrete show significant improvements over 28 days: compressive strength increased by 18%, while flexural and vibration strengths boosted by 39% and 32%, respectively. Experimental findings indicate a 17% reduction in deflection during 4-point bending tests and a 33% decrease in double shear test deflection. Deflection calculations were performed using energy-based approaches, with computed and empirical results aligning within acceptable margins. Notably, electronic and textile waste demonstrate promising potential as effective reinforcements for cement-based concrete.

KEYWORDS: E-waste, Textile fibers, Sustainable concrete, fiber-reinforced concrete,

I. INTRODUCTION

The production of textiles has been rising globally over the past few years. Growing living standards and an increase in the world's population have resulted in a natural demand for textiles due to basic needs, as well as overconsumption from fads in fashion. According to a World Bank report, the quantity of urban useless material created annually is predicted to jump from 1.3 billion to 2.2 billion tonnes worldwide by 2025, representing a 70% increase. Global textile output has steadily increased in recent years. Dumping of solid waste is a serious issue, especially for developing nations. Insufficient handling and elimination of solid waste contaminates the earth and atmosphere, endangering both human well-being and the natural environment. Vasudevan, et al. [1] utilization of waste polymers for flexible pavement and easy disposal of waste polymers. As a result[1], managing textile waste has become increasingly important, and developing countries should set aside a sizable portion of their municipal budgets for waste management. Road networks are essential for giving cars in developing nations like India a long-lasting and safe surface. Pedestrian ways are frequently built put to use bitumen. Concrete pavements are advised, nevertheless, in specific circumstances. Numerous additives have been studied to enhance concrete's functionality as a concrete material. Current study, fibre-hold-up concrete has a very high strength and other desirable properties that make it acceptable for use in pavement construction. According to ACI Committee 544, FRC is defined as "fiber-reinforced Concrete consists of cement, water, and fine and coarse gravel that is used to create discontinuous fibers and cementitious qualities. Various fibers, including steel, polymer, and natural fibers, are utilized. As previously stated, fiber-reinforced concrete is a type of concrete that occurs when yarns are used as support in order to enhance concrete's mechanical properties as well as strength.

In addition to providing local strengthening in the tensile area, fiber-reinforced concrete also increases compression and tension, decreases deflections and shrinkage, and increases ductility. In addition to the qualities already listed, polymeric fibers aid in reducing corrosion. Recron 3s, polyester, and polypropylene are frequently utilized in FRC applications. Nemade et al. [2] Utilization of polymer waste for modification of bitumen in road construction.

Lately, additional recycled fiber types are also being used for the same purpose, including plastic, tires that have been disposed of, carpet waste, and textile industry waste. These materials serve mainly as split arresters. Fibers aid in preventing small cracks from becoming larger ones by resisting them. This causes the material to change into one that is more resilient to failure and has better ductility. It may be successfully reinforced in concrete to get additional power and use it for pavements since concrete is weak in tension and impacts on its own. It has been established that fiber-incorporated concrete provides additional strength in flexure, condensing, tiredness, and affect. Electronic trash includes a wide spectrum of abandoned electronic items, such as computers, mobile phones, televisions, and home appliances. The fast growth of technology, coupled with the reduction in the lifespan of electronic equipment, has resulted in an exponential increase in e-waste creation. According to the Global E-Waste Monitor, roughly 53.6 million metric tons of e-waste were created globally in 2019, with this amount expected to increase to 74.7 million metric tons by 2030. E-waste contains dangerous compounds including lead, mercury, and cadmium, which can pose serious environmental and health problems if not properly treated. However, e-waste contains valuable elements like as metals, polymers, and glass, which may be recovered and reused. Figure 1 is showing shredded electronic waste.

Figure 1: Shredded electronic waste

Recycling e-waste not only reduces environmental risks, but also recovers valuable resources. Metals including gold, silver, copper, and palladium may be retrieved from electrical gadgets. The recycling process entails disassembling the gadgets, sorting the components, and recovering these precious elements using a variety of chemical and mechanical methods. Integrating e-waste into concrete manufacturing can provide a long-term solution for its disposal, lowering the requirement for virgin resources and encouraging resource conservation. Musa et al. [3] utilization of synthetic reinforced fiber in asphalt concrete. Textile waste is another big environmental problem, and the fashion sector is one of the main contributors. Textile manufacture requires a substantial amount of resources, including water, electricity, and chemicals. Furthermore, the disposal of textile items creates significant waste, with millions of tons of garments ending up in landfills each year. According to the Ellen MacArthur Foundation, fewer than 1% of the material needed to make new garments is recycled, resulting in a considerable waste of precious resources. Textile waste includes both natural fibers like cotton and wool and synthetic fibers like polyester and nylon. These materials, when correctly treated, can be used in a variety of building applications [4].

The use of textile waste in concrete has the potential to improve its mechanical qualities. For example, textile fibers can improve the tensile strength and fracture resistance of concrete, resulting in more lasting and robust constructions. Additionally, using textile waste in concrete minimizes landfill volumes and the environmental effect of textile disposal. By recycling textile fibers into concrete, the building sector may help to create a circular economy in which waste resources are continually reused and repurposed. Pranav et al. [5] Alternative materials for wearing course of concrete pavements:

- ***Use of electronic waste and textile waste***

The inclusion of e-waste and textile fibers into concrete has various potential advantages. First, it may improve concrete's mechanical qualities, such as compressive strength, flexural strength, and shear strength. These enhancements can result in more durable and resilient road pavements, lowering maintenance costs and prolonging their useful life. Second, using waste materials in concrete can limit the quantity of garbage that ends up in landfills, reducing the environmental impact of waste disposal. Furthermore, recycling e-waste and textile trash may recover valuable materials, which helps to conserve resources and reduces demand for virgin materials.[6] Alternative materials for wearing course of concrete pavements.

Consumer electronic devices have increasingly shorter lifespans due to rapid advancements in technology, resulting in a growing volume of obsolete electronics known as electronic waste (e-waste). Traditional electronic waste removal methods have significant drawbacks, additionally economically and environmentally.

Therefore, there is a pressing need to explore new e-waste management solutions, such as recycling.

However, the infrastructure for electronic recycling is still in its infancy, lacking established systems. Currently, two primary methods for e-waste disposal exist: landfilling and incineration. Landfilling e-waste contributes to soil and water pollution, while incineration leads to Pollution of the atmosphere. As a result, there is an urgent desire to convert e-waste through beneficial substances that are harmless to the ecosystem throughout their lifetime.[7]

II. MATERIALS AND METHODOLOGY

A. Basic materials

The fundamental documents used to create concrete are water, cement, fine aggregate, and coarse gravel.

This experiment focuses on two types of waste. The waste that will be used in the concrete mix is:

- Electronics waste
- Textile waste

B. Water

- Incredibly an especially vital aspect. It serves several roles in the concrete matrix: The first improves cement adhesion. The total amount and purity of water used affect the quantity, grade, strength, and rate of organization of the adhesive material.
- It also has an impact on how workable concrete is. Increased water content (up to a certain point) improves workability.
- Cement hydration and water content affect the physical characteristics of hardened concrete, like flexural, compressive, and longevity.
- The plasticity of concrete is determined by its water content
- Curing hardened concrete requires water to achieve the required strength.

C. Cement

- When mixed with water, cement demonstrates adhesive and binding properties that consolidate the aggregate into a solid concrete mass. Known as hydraulic cement due to its adhesive characteristics, it undergoes an exothermic hydration process that results in a water-resistant material [8]

- ***Ordinary Portland Cement (OPC)***

Ordinary Portland Cement (OPC) is created by heating calcareous (calcium carbonate) and clay materials to high temperatures. The resulting product, called clinker, is then ground into a fine powder with a small amount of gypsum.

- ***Portland Slag Cement (PSC)***

This cement is manufactured in a similar manner to OPC, but instead of gypsum, blast furnace slag is used to grind the clinker. Meeting the IS 455:1989 standard, this sulfate-resistant cement is ideal for construction in challenging environments.

- ***Portland Pozzolana Cement (PPC)***

According to IS 1489, Portland pozzolana cement (PPC) is manufactured using fly ash residue from heated power plants, clinker, and gypsum. Pozzolana cement is produced by mixing Portland cement clinker with pozzolana. This cement is widely used in maritime construction.

D. Fine Aggregate

Fine aggregate usually consists of regular sand. Quarry dust, also referred to as stone crusher dust, can be utilized as fine aggregate. It makes up an important portion of the concrete framework. Sand plays the following roles in the concrete matrix as follows:

- Fills gaps between coarse aggregates.
- Improves the workability of concrete.
- Reduces split in concrete.
- Reduction of concrete during drying.
- Speeds up the solidification process of concrete.
- Promotes made silicates, a key component of hardened concrete.

However, to be used effectively in concrete, sand must have specific properties. Sand for concrete must meet the following basic requirements:

- Ensure strength and durability.
- Ensure it is free of vegetation and organic matter.
- There should be no silt or clay present.
- Sand should not be hygroscopic in nature.
- The sand ranges from 75 microns to 4.75mm.

E. Coarse Aggregate

Typically composed of crushed stones such as granite. It may also include gravel or broken bricks. The majority of the concrete matrix is composed of coarse aggregate, which contributes to the hardened concrete's weight and strength. Commonly used coarse aggregates include:

- ***Granite Aggregates***

Granite aggregates consist of crushed pieces of dense, granular rock. This rock is formed from hardened magma that has reached the Earth's surface. Granite is highly valued for its properties, including high solidity (with a grade of 1400 - 1600), excellent frost resistance, and low porosity. Granite aggregates come in various particle sizes. A typical sample includes the following:

- ***Granite Sand:*** This refers to the portion of granite aggregate with particle sizes ranging from 0 to 3 mm.
- ***Small Chips***: These are granite aggregate particles ranging in size from 3 to 10 mm, widely used in slab construction.
- ***Chips***: -The most common fraction has dimensions ranging from 5 to 10 millimeters. This granite fraction is used in a wide range of construction projects, including construction, way over, roadway, fillings, drainage structures, and more.
- ***Granules:*** Includes aggregates ranging in size from 10 to 20mm, which are commonly used in paving and flyover projects.

- ***Gravel aggregate***

Crushing natural stone or quarry rock typically produces these particles. Although these aggregates are less strong than granite, they are more economical. They are often used as foundation materials.

- ***Lime aggregate***

It is also known as dolomite aggregates. Harly is used in the construction process. Sedimentary limestone is the basic element of lime aggregate.

- ***Secondary aggregates***

In addition, gathers are produced by pounding building debris such as mortar, brick, or asphalt. The low price of these aggregates makes them superior. Secondary aggregates are smaller than primary aggregates and can be prepared in the same manner.

F. Admixtures

A combination is a chemical-based complex that is combined with other concrete materials prior to or during adding to give the concrete the desired properties. Chemical mixtures are typically used for the following purposes:

Lower forming costs.

- Modify the character of hardened concrete.

Ensure fuse quality is maintained during shipping and placement.

Obtain specific results following a certain time.

There are mainly four types of admixtures:

- ***Water-reducing admixture:*** They are often utilised to reduce the amount of water in concrete mixes. Additives may lower the volume of water by 5–10%. Lowering the proportion of water to cement enables a stronger concrete mix lacking enhancing cement content, implementing the technique cheaper.
- ***Accelerating admixtures:*** - Such additives help a solid reach its bursting point more quickly. It lessens the time necessary for the initial development of power as well as curing. These admixtures are ideal for making concrete in colder regions in which quick durability is crucial.
- ***Retarding admixtures:*** These substances cut the acceleration as the grout expands. The aforementioned tend to be used. Inhibitors: – Blockers fulfill building materials safe from aggressive environmental conditions. It is frequently applied when a concrete structure is subjected to chemical-based incidents, a saline environment, and so on. The admixtures form a protective coating on the concrete structure, preventing it from interacting from occurring to the asphalt or additions within.

- ***Super-plasticizers:*** All of these mixes, also known as plasticizing agents, may lower the required water quantity for solids by 15-30%. Maintain the cement flowable in order to set in heavily confirmed frameworks. The mixtures have a short outcome (30-60 minutes) but contribute to high strength. To mitigate the effect of heat on mortar in high-temperature environments, use concrete buildings.

G. Fibers

They include tiny separate elements composed of a metallic material or polymeric that can be utilized to bolster frameworks made of concrete. All of these interact together with different physical elements to build a structure and impart particular qualities.

- The aforementioned are frequently utilized for enhancing the strength of tensile material.
- Better effects, breaking, and durability against abrasion.
- Boost bendable and shear capacity.
- Minimize the effects of fluctuating temperatures on the material.
- Polymer materials are corrosion-resistant and are capable of being used in salty environments [9]. The materials utilized in the concrete mix include:

- ***53 Grade OPC (Ordinary Portland Cement)****:* This type of cement is known for its high compressive strength and durability, suitable for various construction applications.
- ***Zone IV Sand****:* Used as fine aggregate, Zone IV sand is carefully graded to ensure optimal packing density in the concrete mix, enhancing its workability and strength.
- ***Coarse Aggregates****:* Two sizes are used - 12mm and 22mm. Coarse aggregates provide bulk to the concrete mix and contribute to its mechanical properties.
- ***Textile waste***
- ***Electronic waste***

Particulate matter of varying quality are dealt with using different IS filters before being stored in separate containers with appropriate labels.

I. Preparation of fibers

The yarn was created using electronic waste as a raw material. Electronic waste is collected, washed, and cleaned at heated water for 2-3 hours prior to being dried. Similarly, textile waste is collected. Aside from textile waste, the contents are removed, washed in hot water, and dried for 1-2 hours. Dried electronic and textile waste is divided into 20mm x 8mm pieces. This ensures that when the fibres combine together with the cement and aggregate, they are thoroughly mixed and evenly distributed throughout the concrete matrix.

- ***Specific Gravity of Cement****:* The specific gravity of the cement used is 3.24. The grade of cement is OPC 53, which denotes Ordinary Portland Cement with high compressive strength and durability.
- ***Specific Gravity of Fine Aggregate****:* The specific gravity of the fine aggregate is 2.63. Fine aggregates, such as sand, are crucial components in concrete mixes, contributing to the workability and strength of the concrete.
- ***Zone of Sand****:* The sand used is classified as Zone IV. Zone IV sand is characterized by its particle size distribution, which influences the packing density and workability of the concrete mix. These properties are essential parameters that influence the quality and performance of the concrete mixture, ensuring it meets the desired specifications for construction applications [10] **Yang, J. M.**, Shin, H. O., & Yoo, D. Y. (2017). Benefits of using amorphous metallic fibers in concrete pavement for long-term of concrete pavements: A critical review. *Construction and Building Materials*, *236*, 117609.

The specific gravity of coarse aggregate = 2.73
Dimension of fibers = 20mm x 8mm
Specific gravity of electronics waste
= 0.94
Specific gravity of textile = 1.12
This information presented above is utilized to design a mix and batch substance to produce a solid with the needed indicative power.

J. Mix Design

The concrete mix design aims to ensure that the concrete is both workable and possesses the necessary strength, hardness, and durability once it hardens. The design mixes M30, M35, and M40 conform to IRC 44:2008 specifications. The materials used in the mix are specified as follows:

A. Cement: OPC 53 grade
B. Fine aggregate: Zone 4
C. Coarse aggregate: Crushed rock (12mm and 22mm)
D. Admixture: Plasticizer

Key design considerations:

- The water-cement ratio was selected within the range of 0.43 to 0.48.
- Coarse aggregates of 12mm and 22mm sizes are used in an 80:20 ratio.
- For fiber reinforced concrete, electronic waste and textile fibers are incorporated at 1.5% by volume of the concrete mass.

These specifications ensure that the concrete mixes meet the required performance criteria while optimizing the use of materials for strength and durability.In the table 1 the design mix proportion is shown here.

Table 1: Design Mix

Component	M30	M35	M40
Water	0.45	0.43	0.40
Cement	1	1	1
Fine Aggregate	2.2	1.7	1.9
Coarse Aggregate (12mm)	3.04	2.8	2.65
Coarse Aggregate (22mm)	0.33	0.31	0.30
Admixture	0.020	0.021	0.022

This table outlines the proportions of water, cement, fine aggregate, coarse aggregate (12mm and 22mm), and admixture for concrete grades M30, M35, and M40. These mix designs are formulated to meet specific performance requirements based on their intended applications.
Given the specific gravity values:

- Electronic waste: 0.94
- Textile fibers: 1.14

The following tests should be performed to evaluate the fiber-reinforced concrete elements that impact pavement durability with little maintenance.

Tests on aggregates:

- Abrasion resistance
- Impact resistance
- Crushing resistance

K. Tests on Aggregate

- ***Abrasion resistance test on aggregates***

Procedure for Los Angeles Abrasion Test:

- ***Preparation of Aggregates:*** Dry the aggregate samples in an oven set at a temperature of 105-110°C until a stable weight is achieved. Based on the grading, use 1250 grams for each of the following sizes: 40-25 mm, 25-20 mm, 20-12.5 mm, and 12.5-10 mm. Include 12 steel balls with the samples.
- ***Initial Weight Measurement***: Weigh a 5 kg sample of the dried aggregates and place it in the cylinder of the Los Angeles abrasion testing machine (initial weight, W1).
- ***Machine Operation:*** Rotate the cylinder at a speed of 30-33 revolutions per minute (rpm) for a total of 500 revolutions.
- ***Post-Rotation Handling:*** Stop the machine after completing 500 revolutions. Remove all material, including the dust generated during the test.
- ***Sieving:*** Sieve the collected material using a 1.7 mm sieve to separate the finer particles.
- ***Cleaning and Drying:*** Clean the retained aggregate on the sieve, dry it in an oven for 24 hours, and then weigh it (weight after drying, W).
- ***Weight of Fines:*** Measure the weight of the fine particles that passed through the 1.7 mm sieve (recorded as W2).

The Los Angeles abrasion value (LAAV) is calculated using the formula:
LAAV=(W1/W2)×100
In this specific test:

- W1 is the initial weight of the sample (4000 grams).
- W2 is the weight of fines passing through the 1.7 mm sieve (1200 grams).

This test evaluates the aggregate's resistance to abrasion, which is critical for assessing its durability in practical applications.

So LAAV = $\frac{W_2}{W_1}$ x100

= 1200 x 100/4000

= 30%

L. Aggregate Impact resistance test.

Procedure for Determining Aggregate Impact Value:

- ***Sample Selection:*** Choose the aggregate sample that passes through a 12.5 mm IS sieve and is retained on a 10 mm IS sieve.
- ***Filling the Cylindrical Cup:*** Place the aggregates into the cylindrical cup of the impact testing machine in three equal layers. Each layer should be tamped 25 times using a tamping rod.
- ***Leveling and Weighing***: Remove excess aggregates using the tamping rod to level the surface, then measure the net weight of the aggregates (denoted as W1).
- ***Impact Application:*** Raise the hammer to a height of 38 cm above the top surface of the aggregates in the cup and let it fall freely onto the sample.
- ***Applying Blows:*** Allow the hammer to deliver 15 blows to the aggregate sample.
- ***Sieving Crushed Aggregates***: After the hammering, sieve the crushed aggregate through a 2.36 mm IS sieve.
- ***Recording Weight of Fines***: Measure the weight of the material that passes through the 2.36 mm sieve (recorded as W2).

The Impact Value is calculated to express the aggregate's resistance to impact, using the formula:
Impact Value=(W1/W2)×100
This test helps evaluate how well aggregates can withstand sudden impact loads, which is crucial for assessing their suitability in various construction applications.

Impact value = $\frac{W_2}{W_1}$ x100

M. Aggregates Crushing resistance test.

Procedure for Determining Aggregate Crushing Value:

- ***Sample Preparation:*** Select aggregates that pass through a 12.5 mm sieve and are retained on a 10 mm sieve for the test.
- ***Filling the Cylinder:*** Take a 3.23 kg sample of the aggregate and fill it into the test cylinder in three layers. Each layer should be tamped 25 times.
- ***Leveling and Weighing***: Level the aggregates at the top surface and record the weight of the test sample as W1.
- ***Setting Up the Test:*** Place the cylinder containing the test sample and plunger on the base plate of the compression machine.
- ***Applying Load:*** Apply load at a consistent rate of four tons per minute until a total load of forty tons is reached.
- ***Sieving Crushed Aggregates:*** Sieve the crushed aggregate through a 2.36 mm IS sieve.
- ***Recording Weight of Fines:*** Measure the weight of the material that passes through the 2.36 mm sieve (denoted as W2).

This test helps determine how well aggregates can withstand crushing loads, which is essential for evaluating their suitability in construction applications.
The crushing resistance of the aggregate is then expressed in terms of crushing value.
Crushing value of aggregate = $\frac{W_2}{W_1}$ x100
The experimental data is tabulated in table 2.

Table 2: Aggregate Testing Results

Los Angeles Abrasion Test	Impact Value Test	Crushing Value Test
• For fiber reinforced concrete the max abrasion value is= 30% • Average value is = 30%	• For fiber reinforced concrete max impact value allowed is = 45% • Average Test results value = 17.61%	• For fiber reinforced concrete the maximum crushing value = 30% • Average Test result value = 19.63%

N. Curing and casting

Concrete compression tests are carried out using standard-sized cubes measuring 150mm x 150mm x 150mm. However, for beams, non-standard dimensions are used: 500mm x 100mm x 75mm.
Samples casted include:

- **Cubes**:
  - Three specimens using M30 ordinary concrete
  - Three specimens using M35 ordinary concrete
  - Three specimens using M40 ordinary concrete
  - Three specimens using M30 fiber reinforced in concrete
  - Three specimens using M35 fiber reinforced in concrete
  - Three specimens using M40 fiber reinforced concrete
- **Beams**:
  - Six specimens using M30 ordinary concrete
  - Six specimens using M35 ordinary concrete
  - Six specimens using M40 ordinary concrete
  - Six specimens using M30 fiber reinforced in concrete
  - Six specimens using M35 fiber reinforced in concrete
  - Six specimens using M40 fiber reinforced in concrete

In total, 36 beams and 18 cubes were cast. They were left in the moulds for 24 hours before being placed in water for curing. After 28 days, the specimens were removed from water and dried and subjected to examination.
This procedure ensures a comprehensive evaluation of both ordinary and fiber reinforced concrete mixes under controlled curing conditions to assess their strength and durability characteristics after the specified curing period.

O. Test on concrete

- ***Compressive strength test***

The compressive strength test is essential for assessing the ability of concrete to withstand crushing loads. The procedure for conducting this test on casted cubes is as follows:
Procedure:

- Clean the bearing surface of the compression testing machine.
- Place the concrete cube sample on the machine with the load applied to the opposing sides of the cube facing the bearing.
- Ensure the sample is centrally positioned on the base plate of the machine.
- Lower the movable portion of the machine until it contacts the top surface of the cube.
- Apply the load gradually and uniformly without any sudden shocks.
- Continuously apply the load at a rate of 140 kg/cm²/min.
- Record the maximum load at which the sample fails. Reverse the direction of the movable portion of the machine to remove the broken sample.
- Clean the bearing surface of the machine again for the next test.

This standardized testing procedure ensures consistent and reliable evaluation of concrete's strength characteristics under compressive loading conditions.
Similar tests were conducted on both ordinary concrete and fiber-reinforced concrete cube samples to determine their 28-day compressive strength using the standard formula.

$f_{ck}=P/A$

where P= load at failure A=Surface area on which the load is applied. For an area of 150mm x 150mm:
A=150 mm×150 mm=22,500 mm
In fig 2 compressive strength machine showen below

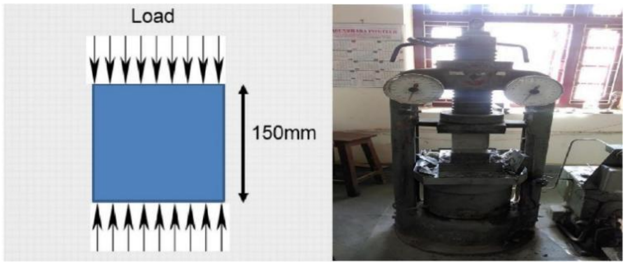

Figure 2: Compressive strength

P. (2-Point load test) 4-Point bend test

Flexural strength, an essential property of concrete, measures its resistance to bending.
The flexural strength of casted beams is evaluated using a 4-point bend test equipment.
Test Procedure:

- Adjust the support and loading pins to the required length.
- Position the beam on the support pins ensuring equal clearance on both sides.
- Raise the loading pins until they contact the upper surface of the beam.
- Set up a dial gauge to measure deflection at the center point.
- Determine the failure load and center point deflection for both conventional and fiber-reinforced concrete beams using the same approach.
- Measure the deflection of concrete beams at specific load intervals for one sample of each grade (M30, M35, and M40) and type (ordinary and fiber-reinforced concrete), and plot deflection versus load.

This procedure ensures accurate assessment of flexural strength, helping to characterize concrete's ability to withstand bending stresses in various construction applications The flexural strength of beams is computed using the following formula:
σ = (PL/bd2)
where P = load applied.

- P represents the load applied.
- L denotes the effective span, which is 400 mm.
- b signifies the width of the sample, measured at 100 mm.
- d indicates the depth of the sample, which measures 75 mm.

The results for compression test for ordinary and fiber reinforced concrete cubes are tabulated in table 3 and table 4 respectively.

Table 3: Compressive Strength Of Ordinary Concrete

Grade of Concrete	Specimen No.	Failure Load (tons)	Compressive Strength (n/mm^2)	Mean Compressive Strength (n/mm^2)
M30	1	79	35.11	35.7
	2	80	35.55	
	3	82	36.44	
M35	1	92	40.88	42.07
	2	95	42.22	
	3	97	43.11	
M40	1	107 109 108	47.55 48.44 48	47.99
	2			
	3			

Table 4: compressive strength of reinforced concrete

Grade of concrete	Specimen no.	Failure load (tons)	Compressive strength (n/mm^2)	Mean compressive strength (n/mm^2)	Strength gain (%)
M30	4	88	39.11	39.55	10.78
	5	89	39.55		
	6	90	40		
M35	4	101	44.88	45.91	9.1
	5	103	46.29		
	6	105	46.66		
M40	4	110	48.88	50.7	5.4
	5	115	51.11		
	6	113	50.22		

Fig 3 is showing 4-point bend test machine and diagram which is shown below.

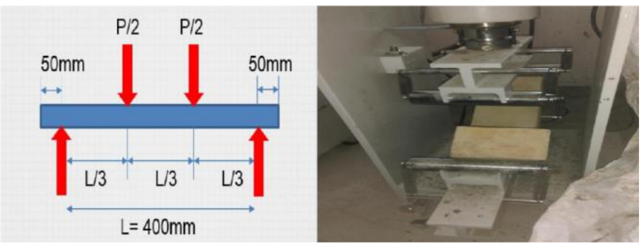

Figure 3: 4 Point bend test

Table 5 show the results of the 4-point bend test for fiber reinforced concrete cube.

Table 5: Fiber reinforced concrete beams strength in flexure

Grade of concrete	Specimen number	Failure load (KN)	Flexural strength (N/mm^2)	Mean flexural strength (N/mm)	Deflection (mm)	Mean deflection (mm)
	4	6.53	4.64		0.069	
M30	5	6.45	4.58	4.61	0.068	0.068
	6	6.5	4.62		0.067	
M35	4	6.92	4.92	4.84	0.066	0.067
	5	6.81	4.84		0.069	
	6	6.7	4.76		0.068	
M40	4	7.07	5.02	5.03	0.062	0.0623
	5	7.08	5.03		0.064	
	6	7.12	5.06		0.061	

The percentage gain in strength and percentage reduction in deflection caused by the introduction of fibers in concrete are computed and summarized .the results of the computations are reported in table 6.

Table 6: Increase in flexural strength and reduction in deflection observed in Fiber-reinforced concrete beams.

Grade of concrete	Mean flexural strength (N/mm^2)	Gain in flexural strength (%)	Mean deflection (mm)	Reduction in deflection (%)
M30	4.61	20.36	0.068	26.47
M35	4.84	20.69	0.067	23.88
M40	5.03	22.08	0.0623	19.26

Table 7 and 8 show the load and deflection coordinates for ordinary and fiber reinforced concrete beams.

Table 7. Represents Loading and deflection data comparison between (M30) ordinary concrete and the Fiber-reinforced concrete beams

Ordinary concrete		Fiber Reinforced Concrete	
Load (KN)	Deflection (mm)	Load (KN)	Deflection (mm)
0	0	0	0
1	0.007	1	0.005
2	0.019	2	0.012
3	0.033	3	0.023
4	0.055	4	0.037
5	0.071	5	0.044
5.4	0.083	6	0.052
		7	0.063
		7.5	0.072

Table 8: Represents Loading and deflection data comparison between ordinary concrete and fiber reinforced concrete beams (M40)

Ordinary Concrete		Fiber Reinforced Concrete	
Load (KN)	Deflection (mm)	Load (KN)	Deflection (mm)
0	0	0	0
1	0.012	1	0.006
2	0.019	2	0.012

3	0.032	3	0.025
4	0.044	4	0.033
5	0.065	5	0.039
5.75	0.077	6	0.047
		7	0.053
		8	0.062
		8.08	0.069

Q. *Test for Double shear*

Shear strength is a fundamental property of concrete, indicating its ability to withstand shear forces. To evaluate the shear strength of casted beams, a compression testing machine is used with the following procedure:

Procedure:

- Adjust the support and loading pins to the required length.
- Position the beam securely on the supports.
- Rotate the detachable part of the machine until it makes contact with the steel plate at the base.
- Apply stress gradually and uniformly to the beam without abrupt impacts.
- Apply the load continuously at a rate of 140 kg/cm²/min.
- Record the load at which the beam fails.
- Reverse the direction of the detachable component to remove the damaged sample.
- Record and plot the deflection of concrete beams at specific load intervals for each concrete grade (M30, M35, and M40) and type (ordinary and fiber reinforced concrete) against load.

This testing procedure ensures accurate assessment of concrete's shear strength, essential for determining its ability to resist shear forces in practical construction scenarios. The flexural strength of beams is computed using the following formula:

$\sigma=(P/bd)$

where P = load applied.

B= width of specimen =100mm

d = depth of specimen = 75mm

Double shear diagram is shown below in fig 4

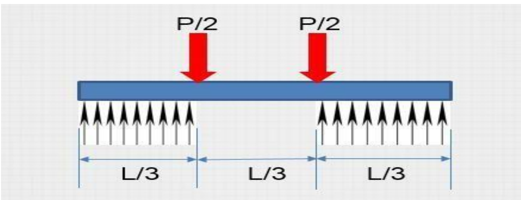

Figure 4: Double shear

The results for double shear test for ordinary concrete cubes and fiber reinforced concrete cubes are tabulated in table 9 and table 10 respectively.

Table 9: Shear strength of ordinary concrete beams

Grade of concrete	Specimen number	Failure load (KN)	Shear strength (N/mm²)	Mean shear strength (N/mm²)	Deflection (mm)	Mean deflection (mm)
	1	62.4	8.32		0.67	
M30	2	61.29	8.172	8.267	0.71	0.69
	3	62.36	8.31		0.69	
	1	63.52	8.46		0.62	
M35	2	63.61	8.48	8.47	0.67	0.68
	3	63.71	8.49		0.75	
	1	64.03	8.53		0.62	
M40	2	64.10	8.54	8.54	0.65	0.626
	3	64.16	8.55		0.61	

Table 10: Shear strength of fiber reinforced concrete beams

Grade of concrete	Specimen number	Failure load (KN)	Shear strength (N/mm²)	Mean shear strength (N/mm²)	Deflection (mm)	Mean deflection (mm)
	4	74.32	9.90		0.52	
M30	5	74.44	9.92	9.92	0.55	0.54
	6	74.56	9.94		0.56	
	4	75.38	10.05		0.55	
M35	5	75.68	10.09	10.09	0.54	0.543
	6	75.96	10.01		0.54	
	4	76.32	10.17		0.52	
M40	5	76.40	10.18	10.18	0.54	0.53
	6	76.49	10.19		0.55	

The percentage gain in strength and percentage reduction in deflection caused by the introduction of fibers in concrete are computed and summarize. The results of the computation are reported in table 11.

Table 11: Shear strength gain and deflection reduction in fiber reinforced concrete beams

Grade of concrete	Mean shear strength (N/mm²)	Gain in shear strength (%)	Mean deflection (mm)	Reduction in deflection (%)
M30	9.92	19.99	0.54	27.57
M35	10.09	19.12	0.543	25.23
M40	10.18	19.2	0.53	18.11

Table 12 and table 13 show the load and deflection coordinates for ordinary and fiber reinforced concrete beams.

Table 12: Load and deflection of ordinary concrete and fiber reinforced concrete beams (M30)

Conventional concrete		Fibre introduced concrete	
Load (KN)	Deflection (mm)	Load (KN)	Deflection (mm)
0	0	0	0
10	0.13	10	0.07
20	0.25	20	0.12
30	0.32	30	0.18
40	0.43	40	0.22
50	0.57	50	0.27
60	0.62	60	0.32
64	0.67	70	0.37
		80	0.42
		84	0.43

Table 13: Load and deflection of ordinary concrete and fiber reinforced concrete beams (M35)

Conventional concrete		Fiber introduced concrete	
Load (KN)	Deflection (mm)	Load (KN)	Deflection (mm)
0	0	0	0
10	0.09	10	0.04
20	0.19	20	0.07
30	0.32	30	0.12
40	0.43	40	0.18
50	0.54	50	0.24
60	0.62	60	0.32
64	0.63	70	0.36
		80	0.43
		85	0.44

III. RESULT AND DISCUSSION

To compare the calculated deflection values with actual measurements, certain standard values and calculations are considered:

A. ***Poisson's ratio (µ)***: Typically taken as 0.2.

B. ***Modulus of Elasticity (E)***: Calculated using the formula (E) = 5000 $\sqrt{f_{ck}}$

Where f_{ck} = characteristic strength of concrete

For M30 the modulus of elasticity is E =27386.13 MPa

For M35 the modulus of elasticity is E = 29580.40 MPa

For M40 the modulus of elasticity is E = 31622.77 MPa

As in the case of fiber-reinforced concrete, the mean of the cube strengths is taken into account; the same is true for traditional concrete.

C. ***Moment of inertia*** *(I)*: Calculated using the formula = $bd^3/12$

$= 100x75^3/12$

$= 3515624\ mm^4$

To compare the calculated deflection values with actual measurements, certain standard values and calculations are considered, these calculations are essential for determining the theoretical deflection of beams under load, which is then compared with actual measurements to validate the accuracy of structural analysis and design assumptions.

D. 4-Point bend test

At the centre of the span the deflection is calculate using the formulae,

$\delta = (23PL^3/1296EI) \times [1+ \{216d^2(1+ \mu)/115L^2\}$

For the $\delta <$ L/900

adjusted as $\delta = 1.5\delta$

For the $\delta >$ L/900

adjusted as $\delta = 8\delta$

The Calculated Deflection values are calculated using the approach described above. Tables 14 and 15 present the Calculated and Actual deflection values for ordinary and fiber-reinforced concrete. Table 16 presents a comparison of Calculated and Actual data.

Table 14: Calculated and Actual deflection of ordinary concrete

Grade of concrete	Specimen no	Failure load (kn)	Theoretical deflection (mm)	Experimental deflection (mm)
M30	1	5.3	0.093	0.082
	2	5.4	0.0945	0.089
	3	5.5	0.096	0.087
M35	1	5.56	0.0915	0.083
	2	5.67	0.090	0.085
	3	5.72	0.0915	0.081
M40	1	5.87	0.090	0.072
	2	5.75	0.0855	0.073
	3	5.81	0.090	0.078

Table 15: Calculated and Actual deflection of fiber reinforced concrete

Grade of concrete	Specimen no.	Failure load (kn)	Theoretical deflection (mm)	Experimental deflection (mm)
	4	4.64	0.079	0.069
M30	5	4.58	0.08	0.068
	6	4.62	0.08	0.067
M35	4	4.92	0.079	0.066
	5	4.84	0.079	0.069
	6	4.76	0.078	0.068
M40	4	5.02	0.076	0.062
	5	5.03	0.075	0.064
	6	5.06	0.076	0.061

Table 16: Comparison of Calculated and Actual deflection

Type of concrete	Grade of concrete	mean theoretical deflection (mm)	mean experimental deflection (mm)	Percentage of variation
Ordinary concrete	M30	0.0945	0.086	8.99
	M35	0.091	0.083	8.7
	M40	0.088	0.074	15.9
Fiber reintroduce concrete	M30	0.0796	0.068	14.57
	M35	0.0786	0.067	14.75
	M40	0.0756	0.062	17.98

E. Double shear test

At the center of the span the deflection is calculate using the formulae,

$\delta = (97PL^3/5078EI)$

For the case $\delta <$ L/900, $\delta = \delta/1.7$

For the case $\delta >$ L/900, $\delta = \delta/2.1$

The theoretical deflection values are calculated using the approach described above. Table 17 and 18 compare the theoretical and experimental deflection values of ordinary and fiber reinforced concrete. Table 19 presents a compression of theoretical and experimental data.

Table 17: Calculated and Actual deflection of ordinary concrete

Grade of concrete	Specimen no.	Failure load (kn)	Theoretical deflection (mm)	Experimental deflection (mm)
M30	1	62.4	0.81	0.67
	2	61.29	0.82	0.71
	3	62.36	0.82	0.69
M35	1	63.52	0.82	0.62
	2	63.61	0.84	0.67
	3	63.71	0.86	0.75
M40	1	64.03	0.80	0.62
	2	64.10	0.82	0.65
	3	64.16	0.84	0.61

Table 18: Calculated and Actual deflection of fiber reinforced concrete

Grade of concrete	Specimen no.	Failure load (kn)	Theoretical deflection (mm)	Experimental deflection (mm)
M30	4	74.32	0.58	0.52
	5	74.44	0.54	0.55
	6	74.56	0.56	0.56
M35	4	75.38	0.57	0.55
	5	75.68	0.59	0.54
	6	75.96	0.55	0.54
M40	4	76.32	0.47	0.52
	5	76.40	0.48	0.54
	6	76.49	0.79	0.55

Table 19: Comparison between theoretical and Actual deflection

Type of concrete	Grade of concrete	Mean theoretical deflection (mm)	Mean actual deflection (mm)	Percentage of variation
Ordinary concrete	M30	0.82	0.67	18.29
	M35	0.84	0.68	19.52
	M40	0.82	0.63	22.6
Fiber reinforced concrete	M30	0.56	0.54	3.57
	M35	0.57	0.54	5.26
	M40	0.58	0.53	8.62

The calculated deflection values for both the 4-point bend test and the double shear test are determined for beams made of ordinary concrete and polymer fiber reinforced concrete across each concrete grade. These calculated deflection values are then compared with experimental deflection values obtained from respective tests under identical physical conditions.

This comparison allows for an assessment of how well the theoretical calculations align with actual experimental results, providing insights into the performance and behavior of both ordinary concrete and polymer fiber reinforced concrete beams under applied loads across different concrete grades (such as M30, M35, and M40).

IV. CONCLUSION AND FUTURE SCOPE

The substance road surfaces are an enhanced alternative to asphalt-like sidewalks for highway road programs, as petroleum-based substances decline. Alternatively offered usual OPC may be utilized in place of bitumen, that is the distillation process outcome of petroleum that is crude. The use of not non-recyclable compounds, such as discarded electronics and textile debris, is a financial and ecologically sound solution for transportation. Waste textile fibres are able to used effectively in concrete. When combined with concrete, both of these products meet the two primary criteria for a pavement material: affordability and low environmental impact.

This might be noticed that FRC made from waste materials such as electronic waste and textile fiber substantially enhances the durability of concrete. The fiber-reinforced concrete showed outstanding resilience with enlargement, flexure, and shear, which are the three essential attributes associated with concrete. Additionally, it solidified the concrete and significantly reduced the movement that it experienced when impacted by outside forces.

The tests conducted on concrete about electronic products trash and fiber from textiles yielded the subsequent outcomes:

- M30, M35, and M40 grade concrete have improved their its compressive strength from 10.75%, 9.5%, and 5.4%, as well.
- Flexural strength increased by 20.36%, 20.69%, and 22.08% in M30, M35, and M40, respectively. The specific decreases in the deflection were 26.47%, 23.88%, and 24.26%.
- Major improvements in strength against shear were observed. M30, M35, and M40 indicated gains in shear strength of 19.99%, 19.12%, and 19.2%, respectively. The respective drops in deviation were 27.57%, 25.23%, and 18.11%.
- According to reports, strength in bending increases exceeding its shear force. Nonetheless, the point of deviation caused by shear force is significantly lower than the rotation caused by flexion.
- Conceptual examination of 4-point bend test results shows that fiber-reinforced concrete has a higher percentage of deviation from deflection when compared to standard concrete, and this percentage increases with increasing indicative strength for both types.
- Standard concrete has a deflection variation of 8.99%, 8.7%, and 15.9% for M30, M35, and M40, while fiber-reinforced concrete has 14.57%, 14.75%, and 17.98%.
- In double shear tests, fiber-reinforced concrete has nearly the same percentage of variation in deflection as ordinary concrete. This percentage increases with increased characteristic strength for ordinary concrete and decreases for fiber-reinforced beams.
- Ordinary concrete has a deflection variation of 18.29%, 19.52%, and 22.6% for M30, M35, and M40, while fiber-reinforced concrete has 3.57%, 5.26%, and 8.62%.
- Based on the aforementioned results, it can be inferred that the inclusion of electronic waste and textile fibers effectively enhances the mechanical properties of fiber-reinforced concrete. These materials have shown positive effects, particularly in improving characteristics such as flexural strength, shear strength, and potentially reducing deflection under load. This suggests their potential utility in enhancing the performance and durability of concrete structures, making them viable options for sustainable construction practices aimed at utilizing recycled materials effectively.

A. *Future Scope*

Advanced Waste Processing Techniques: Research can focus on developing better techniques for processing electronic and textile waste before incorporation into concrete. For example, chemical treatments or mechanical processing methods could further enhance the bonding properties between waste fibers and the cement matrix, improving overall strength and longevity. Exploration of Different Waste Types: Expanding beyond textiles and electronics, future studies could investigate the use of other industrial waste materials, such as plastic, glass, or rubber, in combination with textile fibers. This could lead to novel, eco-friendly composites that further enhance the sustainability of the construction industry. Improving Material Characteristics: With the significant improvements in compressive, flexural, and vibration strengths observed, future research could delve into optimizing the volume ratio of waste materials. Different combinations of textile and electronic waste could be tested to achieve optimal balance in strength, weight, and durability.

B. *Higher Percentages of Waste Material Incorporation:*

- Investigating the effects of incorporating electronic waste and textile fibers at higher percentages, such as 2.0%, 2.5%, and 3.0%, could reveal additional benefits or limitations.
- Evaluating the impact of higher fiber content on the workability, compressive strength, flexural strength, shear strength, and durability of concrete.
- Determining the optimal percentage of waste material that balances enhanced mechanical properties with maintainable workability and structural integrity.

C. *Diverse Concrete Mix Designs*:

- Extending the research to include different concrete grades beyond M30, M35, and M40, such as M50, M60, and higher-strength mixes.
- Assessing how different grades of concrete respond to varying percentages of electronic waste and textile fibers, and identifying the most effective combinations for specific applications.

REFERENCES

[1] R. N. S. K. Vasudevan, S. K. Nigam, R. Velkennedy, A. R. C. Sekar, and B. Sundarakannan, "Utilization of waste polymers for flexible pavement and easy disposal of waste polymers," in *Proc. Int. Conf. Sustainable Solid Waste Management*, Sep. 2007, pp. 5-7. Available from: https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=107ceea57e94ec16cd8ed1ed2dbc0c173b5f2369

[2] S. N. Nemade and P. V. Thorat, "Utilization of polymer waste for modification of bitumen in road construction," *Scientific Reviews and Chemical Communications*, vol. 2, no. 3, pp. 198-213, 2013. Available from: https://shorturl.at/s46kw

[3] N. F. A. A. Musa, M. Y. Aman, Z. Shahadan, M. N. Taher, and Z. Noranai, "Utilization of synthetic reinforced fiber in asphalt concrete–a review," *Int. J. Civ. Eng. Technol.*, vol. 10, no. 5, pp. 678-694, 2019. Available from: https://shorturl.at/zed49

[4] A. Geremew, P. De Winne, T. A. Demissie, and H. De Backer, "Treatment of natural fiber for application in concrete pavement," *Advances in Civil Engineering*, vol. 2021, pp. 1-13, 2021. Available from: https://onlinelibrary.wiley.com/doi/full/10.1155/2021/6667965

[5] S. Pranav, S. Aggarwal, E. H. Yang, A. K. Sarkar, A. P. Singh, and M. Lahoti, "Alternative materials for wearing course of concrete pavements: A critical review," *Construction and Building Materials*, vol. 236, p. 117609, 2020. Available from: http://dspace.bits-pilani.ac.in:8080/xmlui/handle/123456789/4064

[6] M. J. Hasan, M. Afroz, and H. M. I. Mahmud, "An experimental investigation on mechanical behavior of macro synthetic fiber reinforced concrete," *Int. J. Civ. Environ. Eng.*, vol. 11, no. 3, 2011. Available from: https://shorturl.at/A9cLG

[7] J. M. Yang, H. O. Shin, and D. Y. Yoo, "Benefits of using amorphous metallic fibers in concrete pavement for long-term performance," *Archives of Civil and Mechanical Engineering*, vol. 17, no. 4, pp. 750-760, 2017. Available from: https://www.sciencedirect.com/science/article/pii/S1644966517300304

[8] L. Li et al., "Experimental study on flexural toughness of fiber reinforced concrete beams: Effects of cellulose, polyvinyl alcohol and polyolefin fibers," *Journal of Building Engineering*, vol. 81, p. 108144, 2024. Available from: https://www.sciencedirect.com/science/article/pii/S2352710223023240

[9] "Fiber reinforced concrete," The Concrete Institute, Oct. 2013. Available from: https://shorturl.at/87vFh

[10] ACI Committee 544, "State-of-the-art report on fiber reinforced concrete," ACI 544 1.R-96, [Online]. Available from: http://www.forta-ferro.com/pdfs/5441r_96.pdf