IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Eco-Friendly Concrete Solutions: Utilizing Coconut Fiber For Sustainable Construction

Prof. Sathe Pooja.R. [1], Dr. Lodhe Ambadas.D.[2], Uphale Rupesh.R.[3], Sangale Shubham.S.[4], Shaikh Rehan.I.[5]

Assistant Professor and Students, Department of civil Engineering.

Introduction:

Reinforced concrete demonstrates low shrinkage and cracking tendencies during the curing process. This feature enhances its dimensional stability, making it an attractive option for precast elements and components that require precise dimensions. Furthermore, its excellent fire resistance capabilities ensure that structures made with Reinforced concrete maintain their integrity and functionality even at elevated temperatures, which is crucial for fire safety in high-rise and industrial buildings. These properties collectively enhance the material's appeal, positioning it as a competitive alternative to traditional concrete in meeting contemporary construction demands.

Problem Statement

Reinforced concrete, despite its eco-friendliness and mechanical properties, faces challenges such as crack formation, which can affect its structural integrity. Traditional methods, such as visual inspections and manual measurements, can lead to missed detections and inaccurate assessments. Machine learning offers potential solutions, but their integration in predicting cracks and pattern recognition in Reinforced concrete is still in its infancy. This paper reviews existing literature, analyzes machine learning approaches, and emphasizes the need for innovative solutions to enhance crack prediction and pattern recognition in Reinforced concrete beams.

Reinforced Concrete Beams Data Collection

- Gathering data on material composition, environmental conditions, load applications, crack occurrences.
- Identifying features affecting crack formation and propagation.
- Developing machine learning models for accurate crack prediction.
- Evaluating models' performance against real-world data.

Impact of Cracks on Structural Integrity

- Despite the many advantages associated with Reinforced concrete, the material is not impervious to cracking. Cracks can develop due to a variety of factors, including thermal stresses during curing, shrinkage, and mechanical loads. The presence of cracks can severely compromise structural integrity, leading to reduced load-bearing capacity, increased permeability, and, in severe cases, structural failure. This risk is particularly concerning in critical infrastructures, such as bridges, high-rise buildings, and industrial facilities, where the safety and longevity of the structure are paramount.

Limitations of Traditional Methods

- Traditional methods for assessing cracks in concrete, such as visual inspections and manual measurements, are often insufficient for accurately predicting crack development and understanding their patterns. These methods are inherently subjective, relying heavily on the expertise and experience of inspectors, which can lead to inconsistencies and potential oversights. The labour-intensive nature of these methods can also contribute to delays in maintenance and repairs, jeopardizing the structural safety of concrete elements.

Material Used

Reinforced Concrete

- Reinforced concrete is an innovative construction material that uses an alkaline solution to activate aluminosilicate-based materials (such as fly ash, slag, or metakaolin) instead of traditional Portland cement. Reinforced concrete is environmentally sustainable due to its low carbon footprint, high durability, and resistance to heat and chemical attack, making it a promising alternative for infrastructure applications.

Properties and Specifications of Reinforced Concrete

- **Table1. Properties and Specifications of Reinforced Concrete**

Property	Specification
Compressive Strength	Typically, 20-100 MPa, depending on mix design
Tensile Strength	Approximately 2-10 MPa
Flexural Strength	Typically, around 10-12% of compressive strength
Density	2200-2450 kg/m³ (similar to conventional concrete)
Workability	Adjustable by modifying the activator solution and superplasticizers
Setting Time	2-72 hours (varies with curing temperature and mix)
Water Absorption	Lower than ordinary Portland cement (OPC) concrete
Thermal Conductivity	Lower than OPC concrete, around 0.80-1.30 W/mK
pH Range	Highly alkaline, similar to traditional concrete
Shrinkage	Negligible or low shrinkage
Durability	Resistant to sulfate, chloride, and acid attack
Fire Resistance	High thermal resistance, can withstand temperatures up to 800°C

Chemical Composition

The chemical composition of Reinforced concrete depends on the source material. Below is a typical breakdown for fly ash-based Reinforced concrete:

Table 2. Chemical Composition

Compound	Range (%)
Silicon Dioxide (SiO_2)	40-60%
Aluminum Oxide (Al_2O_3)	15-30%
Iron Oxide (Fe_2O_3)	5-10%
Calcium Oxide (CaO)	1-5%
Magnesium Oxide (MgO)	0.5-3%
Sodium/Potassium Oxide	1-5%
Other trace elements	Varies based on source material

Technical Data for Reinforced Concrete

Table 3: Technical Data for Reinforced Concrete

Parameter	Description
Activator Solution	Combination of sodium silicate and sodium hydroxide or potassium silicate and potassium hydroxide
Curing Method	Heat curing preferred (60-90°C), though ambient curing is possible
Water-to-Reinforced Ratio	Ranges from 0.2 to 0.4 depending on mix design
Admixtures	Superplasticizers can be added to improve workability
Environmental Resistance	Excellent resistance to chemicals like sulfates and chlorides, making it suitable for marine and wastewater structures
Service	Projected to exceed traditional

Life	concrete, potentially lasting over 50 years under suitable conditions
Carbon Footprint	Estimated 40-80% lower CO_2 emissions compared to OPC

Mix Design Specifications

Material	Proportion by Weight (%)	Remarks
Source Material (e.g., Fly Ash)	50-70%	Aluminosilicate source
Alkaline Activator	15-25%	Sodium or potassium hydroxide and sodium or potassium silicate solution
Aggregates	60-75%	Coarse and fine aggregates
Superplasticizer	1-2% (optional)	Improves workability
Water	Minimal, as per mix requirements	Helps achieve desired consistency

Coconut Fiber

Physical and Chemical Properties of Coconut Fiber

Property	Description
Physical Properties	
Color	Golden brown to reddish-brown
Diameter	0.1 – 0.6 mm
Length	50 – 350 mm
Density	1.15 – 1.40 g/cm³
Tensile Strength	100 – 250 MPa
Young's Modulus	4 – 6 GPa
Elongation at Break	15 – 25%
Moisture Content	8 – 12%
Water Absorption	High (around 100-200%)
Durability	High resistance to rotting and decay
Chemical Properties	
Cellulose	40 – 45%
Hemicellulose	20 – 30%
Lignin	20 – 45%
Pectin	3 – 5%
Ash Content	0.5 – 1.5%
Extractives	2 – 5%
pH Value	5.5 – 6.5

RESEARCH METHODOLOGY

Quantitative vs. Qualitative Approaches

The research framework for this study provides a comprehensive structure for exploring crack prediction in Reinforced concrete beams through quantitative methodologies. It begins with a rigorous literature review to highlight existing knowledge, identify gaps in current understanding, and formulate targeted research questions that address these gaps. The literature review is crucial, as it not only informs the theoretical background but also helps in refining the study's objectives. Once the framework is established, it guides the experimental design phase, where controlled experiments are carefully planned to investigate the factors influencing crack formation. This structured approach is instrumental in ensuring the reliability and validity of the findings.

Data Collection

In the data collection phase, a meticulous experimental setup is essential for ensuring the integrity of the results. The careful preparation of Reinforced concrete involves selecting high-quality aluminosilicate materials, which can significantly influence the performance characteristics of the final product. For instance, the choice of fly ash versus slag may yield differing strengths and durability profiles, necessitating a controlled approach to material selection and preparation.

Mix Grade Design
M30 MIX DESIGN IS 10262:2019

Concrete Mix Design for M – 30 Grade of Concrete

Following steps for concrete mix design procedure as per IS Code 10262 – 2019

Step-1 Calculate Target Mean Strength of Concrete

In order that not more than the specified proportion of test results are likely to fall below the characteristic strength, the concrete mix has to be proportioned for higher
target mean compressive strength f ’ck.

The Target mean characteristic strength is given by the following relation:

f’ck = fck + 1.65 S or f’ck = fck + X
whichever is higher.
were,
f’ck = Target mean strength (compressive) at end of 28 days, in N/mm2;
S = standard deviation, in N/mm2 (see 4.2.1); and
X = Factor as per Grade of Concrete, as per Table 1.

Value of X for Concrete Mix Design as Per IS Code 10262 – 2019

Table – 2 Assumed Standard Deviation

For M -20 Grade of Concrete,

Standard Deviation for Concrete Mix Design as Per IS Code 10262 – 2019

Target Mean Compressive Strength (f’ck) = fck + 1.65 S
= 30 + 1.65 x 5 (S = 5.0 for M – 30)
= 38.25 N/mm²

Target Mean Strength (f’ck) = fck+ X
= 30 + 5.5
= 35.5 N/mm²

Always select a higher value. Therefore, for the M-30 grade of concrete, we will try to achieve 38.25 N/mm² strength.

Step-2 Selection of Water-Cement Ratio

It is stated for concrete mix design as per is code that in general different types of cement, aggregates of various maximum size and supplementary cementitious materials, grading, surface texture, shape, and other characteristics may produce concrete of different compressive strength for the same free water–cement ratio.

Water-Cement ration Graph for Concrete Mix Design as Per IS Code 10262 – 2019

So, for the M – 30 Grade of concrete, we have a target mean strength of 38.25 N/mm² and we have OPC – 53 grade of cement.

Step-3 Estimation of Air Content

Estimated Air Content for Concrete Mix Design

We have a nominal maximum size of aggregate of 20 mm.

From the above table, the approximate air content as a percentage of the volume of concrete is 1 %

Step-4 Selections of Water Content and Admixture Content

The water content in concrete is generally affected by various factors, such as aggregate size, aggregate shape,aggregate texture, workability, water-cement ratio, cement, and other supplementary cementitious materials type and content, chemical admixture, and environmental conditions.

As aggregate maximum size increases, a reduction in water–cement ratio and slump, and the use of rounded aggregate and water reducing admixture will reduce the water demand.

On another side, if the cement content, slump, water–cement ratio, aggregate angularity, temperature, and a decrease in the proportion of the coarse aggregate to fine aggregate will increase water demand.

Step-5 Estimation of Cement Content

We have water content and water–cement ratio. So, from this data, we can calculate cement content for concrete,

Water-Cement Ratio = 0.475
Water / Cement = 0.475
197.16 / Cement = 0.475
Cement = 197.16/0.475

Cement = 415.07 Kg.

From Table 5 of IS 456, minimum cement content for 'moderate' exposure conditions is 300 kg/m³ but taken 415.07 kg/m³ > 300 kg/m³ hence ok.

Step-6 Estimation of Coarse Aggregate Proportion

It is essential to use the specified nominal maximum size, type and grading will produce concrete of satisfactory workability when a given volume of coarse aggregate per unit volume of total aggregate is used.

Approximate values for this aggregate volume are given in Table 5 for a water-cement/water cementitious materials ratio of 0.45, which may be suitably adjusted for other ratios,

The proportion of the volume of coarse aggregates to that of total aggregates is increased at the rate of 0.01 for every decrease water cement/cementitious materials ratio by 0.045 and decreased at the rate of 0.01 for each increase in a water-cement ratio by 0.045.

Sometimes, it is required more workable concrete such as when placement is by pump or when the concrete is required to be worked around congested reinforcing steel. In such a case, it is desirable to reduce estimated coarse aggregate content determined using Table 5 up to 10 percent.

We have a maximum size of aggregate = 20 mm and which confirming the zone – II.

As per table number 5 of IS 10262:2019 volume of coarse aggregate for 20 mm nominal size aggregate and fine aggregate (Zone III) for having a water–cement ratio of 0.45 =0.475 (a

In the present case, the water–cement ratio is 0.475. Therefore, the volume of coarse aggregate is required to be decreased to increase the fine aggregate content.

As the water–cement ratio is higher by 0.12. the proportion of the volume of coarse aggregate is decreased by 0.014 (at the rate of -/+ 0.01 for every ± 0.05 change in the water-cement ratio).

= 0.12/0.05 = 2.4 % decrease in coarse aggregate content

= 0.475 – 0.62 x(2.4/100)

= 0.475 – 0.014

= 0.461

Therefore, the correct proportion of the volume of coarse aggregate for the water–cement ratio of 0.475 = 0.461

Or pumpable concrete these values should be reduced up to 10%.

Therefore, Coarse aggregate Volume =0.461 x 0.9 =0.4149

Fine Aggregate Volume = 1 – 0.4149 = 0.5841

Step-7 Mix Calculation for 1 m³

Material quantity calculation for concrete mix design as per IS Code – 10262: 2019,

A) Volume of concrete = 1 m³

B) Volume of Air Content wet concrete = 0.01m³

C) Volume of cement = [Mass of cement] / {[Specific Gravity of Cement] x 1000}

= 415/ {3.15 x 1000} = 0.1317 m³

D) Volume of water = [Mass of water] / {[Specific Gravity of water] x 1000}

= 197.15/ {1 x 1000} = 0.197 m³

E) Volume of all in aggregate = [(A-B)-(C+D)]

= [(1-0.01)-(0.1317+0.197)] = 0.99-0.297

= 0.6613 m³

F) Weight of coarse aggregate= E x Coarse Aggregate Volume x Specific Gravity of coarse Aggregate

= 0.6613 x 0.6 x 2.795 x 1000

= 1109.00 kg/m³

G) Weight of fine aggregate= E x Volume of Fine Aggregate x Specific Gravity of Fine Aggregate x 1000

= 0.6613 x 0.46 x 2.517 x 1000

= 765.66 kg/m³

MIX Proportion by Volume

Cement = 415 kg/m³

Water = 197.15 Liter/m³

Fine aggregate = 802.36 kg/m³

Coarse aggregate 20 mm = 1109.16 x 60 %= 665.29 kg/m³
Coarse aggregate 10 mm = 1109.16 x 40 %= 443.6 kg/m³
Water-cement ratio = 0.465

CONCLUSION & FUTURE WORK

Summary of Findings

- Compressive Strength: Reinforced concrete achieves early strength due to rapid Reinforcedization, but strength development continues over time, especially with steel fiber reinforcement.
- Flexural Strength: Steel fibers significantly improve flexural strength by controlling crack propagation and enhancing ductility. Typical improvement: 20-40% over plain Reinforced concrete.
- Split Tensile Strength: Split tensile strength benefits from the bridging effect of steel fibers, contributing to increased tensile resistance. Improvement is typically 15-30%
- Modulus of Elasticity: Modulus of elasticity shows minor improvement with steel fibers and improves over time due to the dense Reinforced matrix.
- Durability: Steel fibers help mitigate cracking under cyclic loading or environmental stress, enhancing long-term durability.

Recommendations for Future Research

The future scope of research in predicting cracks and recognizing patterns in Reinforced concrete beams using machine learning is vast and multifaceted. Building upon the insights gained from this review, several avenues for future exploration can be identified: