*Journal of Harbin Engineering University*
*ISSN: 1006-7043*

Vol 44 No. 10
October 2023

# Impact Analysis and Investigation on Coconut Shell Fibre Reinforced Concrete (CSFRC) Based on Different Loading Condition

**Parthasaarathi R.[1,4], Balasundaram N.[2], Naveen Arasu A.[3], Senthilkumar R.[4]**

[1] Research Scholar, Department of Civil Engineering, Karpagam Academy of Higher Education, Coimbatore, Tamilnadu, India.

[2]Professor & Head, Department of Civil Engineering, Karpagam Academy of Higher Education, Coimbatore, Tamilnadu, India.

[3]Assistant Professor, Department of Civil Engineering, CMS College of Engineering and Technology, Coimbatore, Tamilnadu, India.

[4] Assistant Professor, Department of Civil Engineering, Hindusthan College of Engineering and Technology, Coimbatore, Tamilnadu, India.

Corresponding author: R. Parthasaarathi Research Scholar, Department of Civil Engineering, Karpagam Academy of Higher Education, Coimbatore, Tamilnadu, India

**Abstract**

This experimental research work produce the Characteristics of coconut shell coir fibre-reinforced concrete (CSFRC) composition beneath different % of effect loading conditions. A Cyclic effect load for single and repeated situations for a specimen turned into performed the uses ofdropping weight hammer device. The experimentbecame discovered under the state of plain Cement Concrete's (PCC) and Coconut shell fibre-reinforcd concrete (CSFRC) specimen with a form of cylinder an identified dimension of one hundred fifty mm diameter and top three hundred mm & 100 mm diameter and 150mm peak specimens changed into examined. Critical impact load energies became implemented at the specimens by means of drop hammering impact load test. In the single load impact take a look at, the research of impact pressure, trade of Elastic modulus and the forceful growth issue (DIF) of CSFRC have been determined. The essential harmful of sample PCC and CSFRC became referred to and in comparison. Inside the number of impact checks, the impact of impact loading top at the most compressive stresses and the vital harm sample turned into calculated. The end result statement between impact loading peak and maximum crucial impact check stresses was identified and noted.

**Keywords:** Cyclic load, Critical Impact load, Dynamic increase factor, CSFRC, PCC.

**Graphical Abstract**

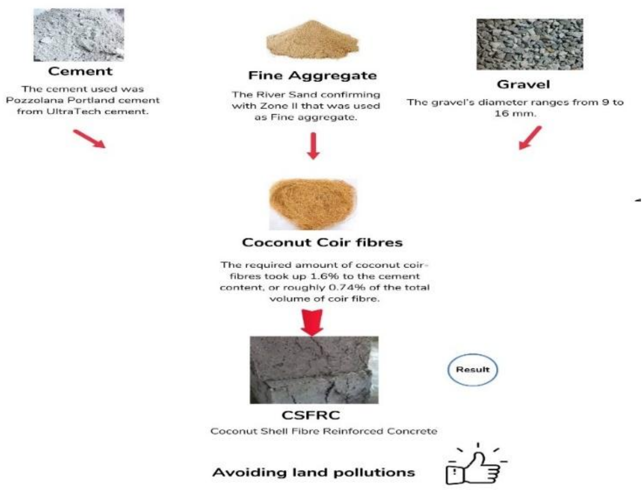



**Fig. 1Graphical Abstract**

## 1. Introduction

In the last few years, there is growing interest in the behaviour and technical needs of Coir fibre-reinforcement concrete. When utilised with reinforced concrete, natural fibres like flax, hemp, jute matrix, and linen'sare found to function well when subjected to static stresses [1- 6]. However, real structures frequently experience loadings that change dynamically, such as those brought on by earthquakes, automobile, plane, and even explosive impacts. Therefore, research into fibre reinforcement concrete under critical effect loads are crucial. Studies on the critical effect of concrete materials have been conducted as well as investigations into various forms of Coir fibre-reinforced concrete composites under critical effect loading [7-9]. For cement concrete beams, Solemani and Banthia et al [8] introduced a cutting-edge drop weight impact test. Each load cell can have a variety of loading caps installed on top, aimed at different load (concentrated load, linear load and surface load). Using photographic recordings, Mindess&Bentur [9] examined the fractured toughness on plain cement concrete (PCC), steel fibre reinforcement concrete (SFRC), glass fibre-reinforced concrete (GFRC). The results revealed that the cracking process during critical impact loading was not considerably different from that under static loading. According to Wang et al. [10], According to the researchers who studied destructive impact testing of SFRC, the steel fibre content was the key variable impacting the reaction of SFRC constructions. Prof Yazici investigated the strength properties of SFRC under dropping weight loading. Several drop weight studies were carried out in order to determine the critical impact fracture energy and the loss of mechanical properties. Conclusion: Compared to non-fibrous concrete, SFRC showed appreciable improvements in impact resistance. Xu et al. [12] studied the tensile properties of spiral steel fibre reinforced concrete when subjected to impact loading. To assess the fracture energy and to obtain dynamic tensile strengths, dynamic splitting tests were conducted. The outcomes showed that the spiral steel fibre-reinforced concrete could successfully resist impact. Concrete shrinkage cracking is effectively controlled by polypropylene fibre [13]. Fibre material was also widely used. used in earlier studies to reinforced concrete. Polypropylene fibre-reinforced concrete constructions displayed ductile failure under impact loading while greatly enhancing energy absorption, according to Nili and Afroughsabet's [14] examination into the impact resistance of concrete. When compared to steel, VPA, and polyolefin fibre-reinforced concrete, polyolefin reinforcement absorbed the least amount of energy. according to Ong et al. [14]. ACI repeated Badr et al. [16] to examine the impact resistance of polypropylene fibre-reinforced concrete used drop weight effect testing and statistical analysis. According to the findings, at least 40 samples should be used in order to produce reliable statistical analysis results.

Some investigators examined the critical effect characteristic of concrete structures using analytical and numerical approaches. For instance, experimental research on ultra high performance fibre-reinforced concrete was done by Habel and Gauvreau [17]. To analyse impact performance, they also used random mass-lent models. The experimental findings and the abstract of model showed good agreement.Natural fibres are gained popularity due to the affordable, environmentally beneficial, long-lasting construction.

Numerous investigations of natural fibre-reinforced concrete have been done by static loading circumstances. For the instance, Chen and Chouw [18, 19] demonstrated the inner flax fibre-reinforced polymer (FFRP) tube can replace the reduced usage of coconut fibre-reinforced concrete (CFRC), and that a weight decreases of double FFRP tube restrict CFRC members are no detrimental effect by the bending hardness. There haven't been many studies done by the impact effect resistance of natural fibre concrete.For instance, Zhou et al. [20] looked at the impact characteristics of short discrete JFRCC cylinders that were 7, 14, and 28 days old. Under impact loadings, JFRCC cylinders showed the fibre failures by pullout. In addition, JFRCC's impact effect resistance decreased with ageing.

On hybrid concrete slabs reinforced with steel and bamboo fibres, Wang et al[21] impact experiments. The hybrid fibre slab had good impact resistance even after first cracking, it was determined. Ramakrishna and Sundararajan conducted more study on natural fibres [22]. When impact loads are applied to reinforced slabs made by four various natural fibresarecoir, sisal's, jute matrix, and hibiscus cannebinu'sthe coir fibre slab proved the most effective at mitigating the effects of the impact.When impact loads are applied to reinforce slabs made of four different natural fibres, coir, sisal, jute, and hibiscus cannebinu's the coir fibre slab proved to be the most effective at mitigating the effects of the impact.

The influence of behaviour of composites made of fibre-reinforced concrete (CSFRC) not done, as far as the authors are aware, been documented.The reaction of CSFRC composites to single and repeated drop weight impact loadings is the main focus of this investigation. The history of the critical impact force, the change in Young's moduli, and the dynamic increase factor (DIF) of CSFRC were all examined in the single impact test. We compared the damage patterns of PCC and CSFRC. The impact height's impact on the maximum compressive stress and the damage pattern was assessed in the repeated drop weight hammer tests. An empirically generated equation that describes the link between impact height and maximum impact stress was proposed.

## 2. Experimental work on raw materials

### *a. Raw Materials*

The components that make up the CSFRC composite specimens are as follows: regular cement, fine aggregate, gravel, water, and brown coconut fibres that were collected from Coimbatore . (Fig.2). The gravel's diameter ranges from 9 to 16 mm. The River Sand confirming with Zone II that was used as Fine aggregate. The diameter of coconut fibres is about 0.35 mm. Cutting the fibres to their final length and omitting the dust particles from the coir fibres were done during the preparation process. A flowchart in Fig. 2&3 illustrates the specifics of coconut fibre processing and was inspired by the account in the work by Ali et al. [23]. Table 1 lists the experimental characteristics of sand, gravel, and coconut coir fibre.



**Fig 2 [Coconut Fibre] Fig 3 [Coconut with minimal Fibre]**

### *b. Mechanical Properties of Coconut fibre, River sand*

**Table 1 [Possible test performed on Aggregates]**

| Aggregate Test | Possible Test Carryout [Yes / No] | | | | |
|---|---|---|---|---|---|
| | Aggregate Class / Grades | | | | |
| | Naturally | | Recycles | | |
| | Granular Material | Sand | Coarse | | Fine |
| | >5mm &<20mm | <5mm | >20mm | >5mm &<20mm | <5mm |
| **Water Content** | P | P | P | P | P |
| **Relative Density** | P | P | P | P | P |
| **Water Absorb value** | P | P | P | P | P |
| **Particle Size Class** | P | P | P | P | P |

**Table 2 [Possible test performed on Coconut Coir's]**

| Coconut Coir Test | Possible Test Performed [Yes / No] | | | | |
|---|---|---|---|---|---|
| | Aggregate Type / Grades | | | | |
| | Natural | | Recycles | | |
| **Water Content** | P | P | P | P | P |
| **Relative Density** | P | P | P | P | P |
| **Water Absorb value** | P | P | P | P | P |
| **Particle Size Class** | P | P | P | P | P |

**Table 3 [Mechanical Properties of Raw Materials]**

| Materials | Dry Density [Kg/m3] | Length(L) [mm] | Dia # [micron] | Tensile Strength [N/mm$^2$] | Elastic Modulus [Gpa] | Elongation at break [%] | Moisture Content [%] | Water Absorption [%] | Fineness Modulus |
|---|---|---|---|---|---|---|---|---|---|
| Coir | 1.24 | 20-150 | 100-130 | 130-245 | 5-7 | 18-22 | - | 160 | - |
| River Sand | 1650 | - | 0.06 | - | 0.089 | - | 5.8 | - | 2.84 |
| Coarse Aggregate | 1540 | - | 22.4 | - | - | - | | | |

***c.Preparation of specimens***

The experimental concretes had a defined compressive strength of 30 MPa and were made of plain cement concrete (PCC), coconut coir shell fibre-reinforced concrete (CSFRC). For simple concrete, the mass ratio to the cement, water, fine sand was 1:0.48:2. It was Pozzolana Portland cement from UltraTech cement that was used. The required amount of coconut coir-fibres took up 1.6% to the cement content, or roughly 0.74% of the total volume of coir fibre. The fibres were 50 mm in length. The design of the CSFRC was identical to that of plain cement concrete, with the exception that coir-fibres were mixed to the mixture and the equal quantity of course aggregate by mass was subtracted from the aggregate's total weight. Table 3 had a list of the precise mix ratio of CSFRC. Before testing, all of the specimens had a 28-day and 56-day cure in the concrete cure room.

Both plain cement concrete (PCC) and CSFRC were made using a concrete mixer. The drum was filled with all the ingredients for basic concrete and revolved for 3 minutes. During a slump cone test, the measured slump was roughly 40 mm.The wet lay-up process were used to evenly split the coconut coir-fibres before casting CSFRC composites. The container is first covered with a course of sand, coir-fibres, cement. Until all of ingredients are added to the mixing pan, this process is repeated. The mixture is then spun for 90 seconds. After adding half of the percentage of water, the mixture was spun for a further two minutes. The CSFRC is currently unworkable. In arrangements to ensure that a material is fully combined and the ingredients are spread throughout the mixes uniformly, remaining water is added to the combination in tray.After that, the mixture is spun for another 90 seconds. The typical slump test measured around 45 mm. For both PCC and CSFRC, cylinders measuring 150 mm by 100 mm were manufactured. For each specific test, a collection of at least three specimens was created.

**3. Experimental Investigation**

**3.1 Testing of static condition**

Twelve cylinders in total were examined. Three were PCC cylinders, and three were CSFRC specimens with 25 mm of coconut coir-fibre

(CSFRC-25), 50 mm of coconut coir-fibre (CSFRC-50), and 75 mm of coconut fibre (CSFRC-75). To calculate the individual crushing strengths and static moduli of elastic limit of these specimens, a compressive test machine was used. Plaster was used to cap each cylinder before testing to make sure that compression load was evenly diffuse across to end surfaces. The ASTM C39/C39M Standard test technique was used to conduct the testing [24].

**3.2 Impact test on specimen**

The drop weight impact machine's description. The impact machine's drop weight is in mentioned in diagram is shown inFig. 4. A mechanical structure of the impact device incorporates a data storage system. A steel structure, guidance element, chain block, and magnetic system make up the mechanical construction. The thousand mm thick, a solid concrete floor is prestressed onto the steel structure. The steel structure is 4 metres tall. Thedropping weight is raised to the different impact heights using a chain hoist. The dropping weight is hold in place up to the user initiates its release by a magnetic mechanism that is remotely controlled. The facilities housing the impact machine sustain minimal damage or disruption as a result of the impact tests' operation. This is so because the strong floor it is supported by has no structural connection to the rest of the building. In order to distribute the stresses communicated to the floor as uniformly as possible, a rubber surface was added to the robust floor surrounding the impact machine.The major component of the test setup is a free-dropping hammer that can be dropped from a height of up to 2.5 m. With a 10 kg increment, impact masses can range from 30 kg to 200 kg.


**Fig. 4The drop weight impact machine is shown in a systematic diagram**

**Table 4. The compositions of mixture ratio:**

| Specimen identification | W/c Ratio | Content of Cement ($Kg/m^3$) | Fine Sand ($Kg/m^3$) | Course Sand ($Kg/m^3$) | Value of Slump [mm] |
|---|---|---|---|---|---|
| PCC | 0.46 | 434 | 866 | 1734 | 42 |
| CSFRC - 10 | 0.54 | 421 | 846 | 1696 | 41 |
| CSFRC - 30 | 0.54 | 421 | 846 | 1696 | 38 |
| CSFRC- 60 | 0.54 | 421 | 846 | 1696 | 38 |
| CSFRC - 90 | 0.54 | 421 | 846 | 1696 | 37 |

**3.3Experimental Instrumentation**

**3.3.1. Loading Cell:**

A piezoelectric force sensor measures the impact force (Model 200C50, PCB Piezotronics). The measuring range's maximum value is 333 kN.PCBPiezotronics also completed the sensors' calibrations, and they have an accuracy of 0.7N.

**3.3.2. Dropping weight hammer test procedure.**

The following dropping weight investigation on CSFRC cylinders was performed. Strain gauges was affixed to the specimens after it had been processed. The specimen was set down on top of the dynamic load cell, which had been set up on the strong floor. The data logger system was then connected to the load sensor and strain gauges. In order to strike a specimen, the 40 kg impact amount is elevated to the target height and then let go. A single drop was used in the impact test on the specimen, but many drops were used in the repeated testing on the same specimen.

**4. Findings and analysis of Results**

**4.1 Test for static compression**

The compressive strengths and elasticity moduli of PC and CSFRC are listed in Table. 5

**Table No.: 5 [Compressive Strength & Modulus of Elasticity]**

| Specimen Type | Fibre Length [mm] | Modulus of Elasticity [Mpa] | Compressive Strength [Mpa] |
|---|---|---|---|
| **PCC** | - | 32.8 x $10^3$ | 33.09 |
| **CSFRC - 10** | 10 | 31.9 x $10^3$ | 33.64 |
| **CSFRC - 30** | 30 | 32.3 x $10^3$ | 33.25 |
| **CSFRC - 60** | 60 | 32.8 x $10^3$ | 32.94 |
| **CSFRC - 90** | 90 | 31.6 x $10^3$ | 32.16 |

**4.2 Results of a single impact test**

**4.2.1 Single impact force results. [Time History]**

This part looked into how the Elastic modulus changed both initial and end of the impact loading. We evaluated PCC, CSFRC to a 60 mm fibre expense (CSFRC-60). In this set of experiments, three distinct heights 50 cm, 100 cm, and 150 cm were taken into account. When the dropping height was greater than 1000 mm and less than 1000 mm of elastic deformation occurred, the specimens began to deform significantly. Only in this section has drop height been taken into account.The impact force is the force that the load cell registered.The maximum impact stress is calculated by dividing the highest impact force by the cross-sectional area. These impact force history of the PCC, CSFRC-60 is shown in Fig. 5. Both types of cylinders experienced impacts for roughly 0.004 seconds.

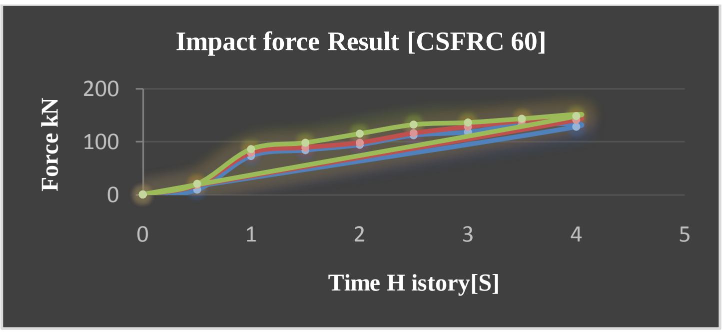



**Fig. 5 [Force to time history graph]**

**Table 6 [Elastic modulus initial and final impact loadings are compared]**

| Specimen Class | Impact Depth [cm] | Elastic Modulus initial impact [$E_0$ in GPa] | Elastic Modulus final impact [$E_o$ in GPa] | Damaged Value [$E_0 – E_1 / E_0$] % |
|---|---|---|---|---|
| **PCC** | 50 | 37.89 [0.89] | 33.80 [0.65] | 10.79 |
| **PCC** | 100 | 37.89 [0.89] | 32.45 [0.89] | 14.36 |
| **CSFRC - 60** | 50 | 38.81 [0.91] | 36.92 [0.82] | 4.87 |
| **CSFRC - 60** | 100 | 38.81[0.91] | 35.42 [0.76] | 8.73 |

**4.2.2 Elastic moduli of PCC and CSFRC cylinders calculated by the impact loading**

Materials are often damaged using material qualities like the moduli of elasticity, strength. In this article, the damaged scenario under dropping weight loading were discussed using moduli of elasticity. Defining damage index D.

$$D = {\partial E}/{Eo} \text{ ---------------------------- (1)}$$

Where $\partial E$ = $E_0$ $–E_1$ represents the change in elasticity moduli because of impact, $E_0$ represents the true elastic moduli of the broken concrete cylinder as determined by static compressive testing, and $E_1$ represents the elastic moduli of the cylinders that has been struck by the free dropping mass.The secant modulus at one-third of the failure stress are referred to as Young's moduli.

In Table 6 displays the PCC's damage index and CSFRC-60 specimens that were subjected to impact loads from drop of 500 mm and 1000 mm.Thus the results showed the elastic moduli of both types of specimens were decreased. Elastic modulus of the PCC samples decreased by 8.73% & 4.83%, which is equal to drop weights from 50 cm and 100 cm, respectively. Similar decrease's in Young's moduli were observed in the CSFRC-60 specimens, with 14.36% (for drops under 50 cm) and 10.79% (for drops under 100 cm), respectively.

However, it was discovered that these two materials' damage patterns were very dissimilar. When a 50 cm here was an impact, neither the PCC nor the CSFRC specimens appeared to have been harmed. However, when bigger impact heights, like 100 cm and 150 cm, were used, there was noticeable damage to the specimens exteriors. Damage to PCC and CSFRC-60 specimens caused by strikes with heights of 100 cm and 150 cm, respectively, is mentioned in Fig. 6. Under a 100 cm drop, the PCC specimen started to show small-scale spalling and fissures. The damage for the CSFRC-60 specimen under the minimal in comparison. A few concrete pieces ripped under impact from a height of 100 cm, leaving facial fissures with lengths of about 3 cm. The CSFRC-60 specimen suffered less severe damage than the PCC specimen for the 150 cm of impact.The PCC cylinder had large-sized cracks and extensive spalling, which decreased the contact area. However, a single 50-cm-long facial crack and slight spalling were found in the CSFRC-60 in the 150-cm impact. The inclusion of coconut shell fibre in CSFRC-60 is thought to be the cause of the PCC specimens suffering less damage. The CSFRC-60 specimens were sprinkled with coconut fibres in an effort to slow the extension of cracks and minimise damage from spalling.

**4.2.3 CSFRC's factor for dynamic increase (DIF)**

In terms of compressive strength, concrete responds differently under impact loading than it does under static stress. In earlier investigations, a Dynamic Increase Flow (DIF) was used as a criteriato determine how compressive strength changed in response to impact loading condition. This part evaluated the DIF in CSFRC under impact load to ascertain the impact's effect on strength of CSFRC composite elements. The adopted fall had a weight of 50 kg and a depth of 2 m.

The DIF was calculated by dividing the compression strength under the impact loading bycorresponding static compression strength. Both the DIF and the European-International Committee for Concrete’s (CEB) were used to forecast the DIF of CSFRC [25].The CEB model's DIF for compression testing is calculated by the following formula:

$$DIF = {fcd}/{fcs} \quad \text{--------------------- (2)}$$

Where

$f_{cd}$ = Compressive Strength in Dynamic, $f_{cs}$= Compressive Strength in Static

A symmetrical strain at a maximum strength is split with time it took to attain this value to get the strain rate in this case [26].DIF results from the investigations are shown in Table 7alongside those derived using the empirical formulae (Equation).It is evident that concrete's compressive strength varies greatly depending on whether a force is static or impact-based. The experiments shown that the DIF is around 1.2.

As a result, concrete's resilience to impact loads are clearly higher than the static loading. Due of concerns about strain rate, this is the case. When it comes to static loading, the strain rate is around 6.2x $10^{-5}$ $S^{-1}$, and in the event of impact loading, it is approximately 2 $s^{1}$. This conclusion is good statement with findings of the majority of earlier studies. According to Pajak[27], who reported the impact of strain rate on the compression strength of concrete, the DIF values between 1 & 2 if the strain rate is 1.5-11 $S^{-1}$.

Similar to regular concrete, the impact behaviour of the natural fibre-reinforced concrete is comparable, with compression strength rising with strain rate [26]. The values of all CSFRC samples with comparable compression strengths proved the measurement of the coconut coir-fibres had little impact on how CSFRC composites behaved when subjected to drop weight loading.

**4.2.4 Impact over time: Test findings**

This section describes the results of continuous impact testing on CSFRC-10, CSFRC-30, and CSFRC -60 and CSFRC-90 specimens. The repeated studies used a drop weight of 40 kg. Nevertheless, various dropping heights were used, the heights were raised until the samples suffered serious crushing damages. The following expression yields the value of impact failure energy.

$$W = P\ (h1 + h2 + \cdots . + hn) \qquad (3)$$

When W denotes the impactsoffailure energy, P is 354 N from dropping weight, $h_1$ denotes the initial drop height (50 cm), $h_2$ is equal to $h_1$, and $h_n$ denotes the dropping height corresponding to the end test number.

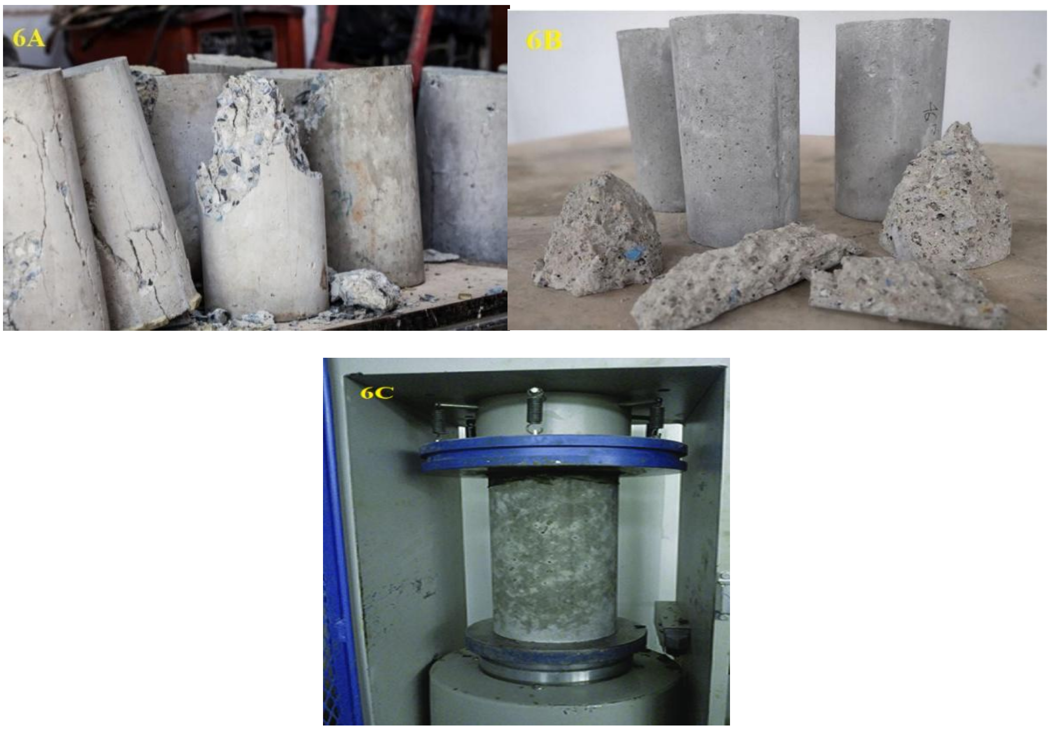
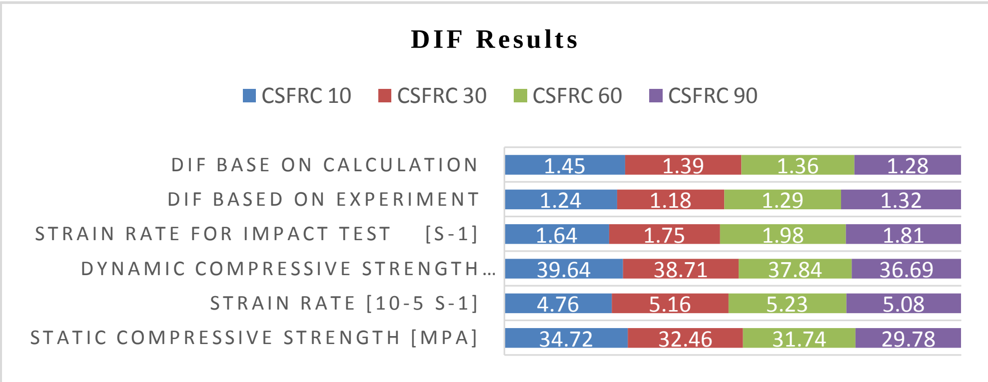



**Fig 6 (Coired Concrete - Cylinder Specimens)**

**Table 7 [DIF results for CSFRC that are calculated]**

| | CSFRC 10 | CSFRC 30 | CSFRC 60 | CSFRC 90 |
|---|---|---|---|---|
| **Compressive Strength under Static [MPa]** | 34.72 | 32.46 | 31.74 | 29.78 |
| **Strain Rate [10-5 S-1]** | 4.76 | 5.16 | 5.23 | 5.08 |
| **Compressive Strength under Dynamic [MPa]** | 39.64 | 38.71 | 37.84 | 36.69 |
| **Impact test strain rate [S-1]** | 1.64 | 1.75 | 1.98 | 1.81 |
| **DIF based on Experiment** | 1.24 | 1.18 | 1.29 | 1.32 |
| **DIF base on Calculation** | 1.45 | 1.39 | 1.36 | 1.28 |

The impact failure energy is W, P is the 354 N drop weight, $h_1$ is the initial drop height (60 cm), $h_2$ is equal to h1, and $h_n$ is the dropping height corresponding to last experiment number, where $h_n = nh_1$.




**4.2.5 The force of impact over time**

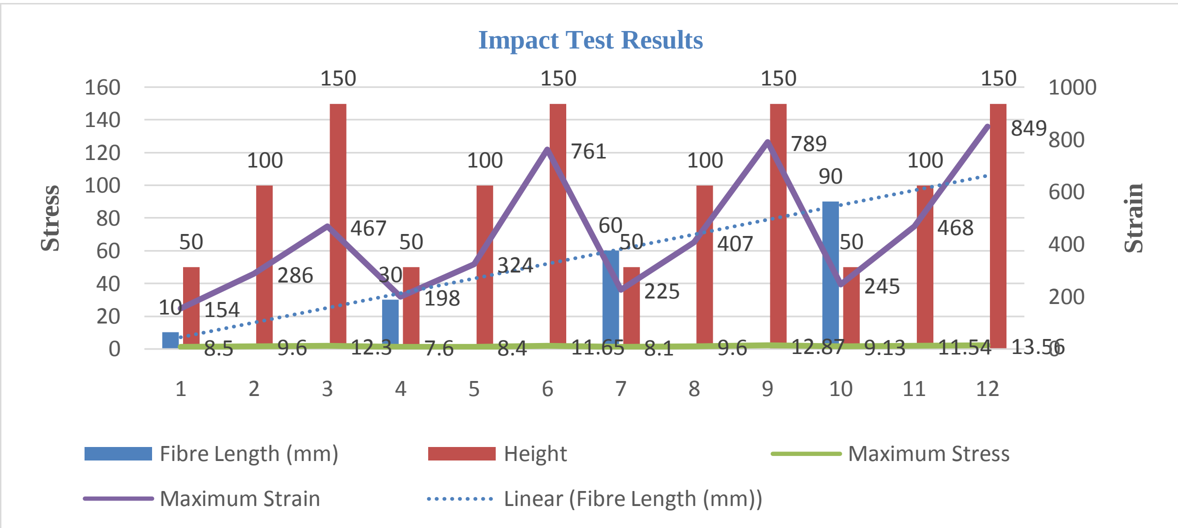
The force of impact history with the specimens of CSFRC-10, CSFRC-30, CSFRC-60, and CSFRC-90 under cyclic loadings is shown in given Fig No. 8. Between and the full impact force happened 0.002 and 0.004 respectively in seconds after the impact, which lasted about 0.006 seconds.The explanations for the time to cap value was the same as for Fig No.5, and it can be found in Section 3.2.1.The quantity of strikes necessary to achieve crushing varied depending on the kind of specimen.Crushing required for four impacts from the drop weight to take place on the CSFRC-30 and CSFRC-60 specimens. When the impact height is 150 cm, crushing happens. Contrarily, just three strikes were required to crush the CSFRC-90 test specimens, meaning the final impact distance could have reached 150 cm.

The highest values of impact pressures, stress, and strain values for various dropping height values are summarised in Table 7.ForCSFRC-10, CSFRC-30, CSFRC-60, and CSFRC-90, the highest impact force values were 164.5 kN, 176 kN, 153.9, and 154.6kN, respectively. For the CSFRC-30 and CSFRC- 60, impact force was increased with the increment in dropping height when the dropping height was lesser than 100 cm. Then the impact forces generated by drop weights of 100 cm and 150 cm was found to be relatively close to another one. This experiment can be explained by the way that damages was demonstrated to manifest in the samples.

Similar relationships way out between compression strength and dropping height for CSFRC-30 mm and CSFRC-60 mm specimens. The maximum stresses were noted from the starting three impact loads, its increasing from 13.1 MPa for 1000 mm to 24.06 MPa for 1500 mm drops, for dropping heights of 30 cm, 60 cm, and 90 cm. The specimen was breaked under the stress at the lastimpact (h = 90 cm), which had a maximum stress that was almost identical to the third impact's. CSFRC-90, on the other hand, was crushed with the third collision.Calculations were used to estimate the test results between impact height and maximum impact stress for the CSFRC-30 and CSFRC-60, and an equation was created.

**Table 8. Summary of repeated impact test results.**

| Fibre Length (mm) | Height (mm) | Impact Energy (Nm) | Impact Force (kN) | Maximum Stress (MPa) | Maximum Strain (μ) |
|---|---|---|---|---|---|
| **10** | 50 | 146.12 | 85.32 | 8.5 | 154 |
| | 100 | 224.67 | 98.45 | 9.6 | 286 |
| | 150 | 395.14 | 145.67 | 12.3 | 467 |
| **30** | 50 | 148.15 | 81.56 | 7.6 | 198 |
| | 100 | 223 | 97.45 | 8.4 | 324 |
| | 150 | 401.18 | 139.34 | 11.65 | 761 |
| **60** | 50 | 149.87 | 89.23 | 8.1 | 225 |
| | 100 | 218.65 | 104.26 | 9.6 | 407 |
| | 150 | 385.5 | 139.78 | 12.87 | 789 |
| **90** | 50 | 148.16 | 82.0 | 9.13 | 245 |
| | 100 | 229.65 | 110.67 | 11.54 | 468 |
| | 150 | 395.34 | 146.45 | 13.56 | 849 |




## 5. Conclusions

Experimental research was done to determine how coconut coir shell fibre-reinforced concrete (CSFRC) cylinder samples respond to dropping weight impacts, both single and repetitive. A total of 60 nos. of specimens were investigated at. The research shows.

A relatively low height of impact (50 cm) on the CSFRC specimens resulted in inner damage, which was inferred from the decrease in tensilemodulus.The results of the trials mentioned that DIF of CSFRC was mostly unaffected by length coconut shellfibres.In the conditions of compressive dynamic strength, inclusion of coconut shell fibres exhibited similar behaviour to that of unadorned concrete. However, the dispersion of coconut shellfibre's bridge function, CSFRC performed better in terms of withstand spalling with fragmentation. It will be advantageous to protect individuals from damaged structures.

**6. Orcid id**

Parthasaarathi Ramaanihttps://orcid.org/0000-0001-9614-0769

**References**

[1] S.H. Ahmad, S.P. Shah,Complete triaxial stress-strain curves for concrete, J.Struct. Eng. 109 (5) 1317–1318 (1982).

[2] M. Mansur, M. Chin, T. Wee Stress-strain relationship of high-strength fibreconcrete in compression, J. Mater. Civ. Eng. 11 (1) 21–29.(1999)

[3] D. Sfer, I. Carol, R. Gettu, G. Etse, Study of the behaviour of concrete undertriaxial compression, J. Eng. Mech. 128 (2) 156–163 (2002).

[4] P.S. Song, S. Hwang, Mechanical properties of high-strength steel fiberreinforcedconcrete, Constr. Build. Mater. 18 (9) 669–673.[5] (2004).

[5] F.A. Silva, B. Mobasher, R.D. Toledo Filhoa, Cracking mechanisms in durablesisal fibre reinforced cement composites, Cement Concr. Compos. 31 (10)721–730 (2009).

[6] L. Yan, A. Duchez, N. Chouw, Effect of bond on compressive behaviour of flaxfibre reinforced polymer tube-confined coir fibre reinforced concrete, J. Reinf.Plast. Compos. 32 (4) 273–285 (2013).

[7] N. Banthia, S. Mindess, J.F. Trottier, Impact resistance of steel fibre reinforcedconcrete, ACI Mater. J. 93 (5) 472–479 (1999).

[8] S.M. Soleimani, N. Banthia,A novel drop weight impact setup for testingreinforced concrete beams, Exp. Tech. 38 (3) 72–79 (2014).

[9] S. Mindess, A. Bentur,A preliminary study of the fracture of concrete beamsunder impact loading using high speed photography, Cem. Concr. Res. 15 (3)474–484(1985).

[10] H. Wang, Y. Zhou, X. Tang, Study on destructive effect of SFRC under strongimpact load, Adv. Mater. Res. 765–767 (5) 3204–3208 (2013).

[11] S_. Yazıcı, H.S_. Arel, V. Tabak ,The effects of impact loading on the mechanicalproperties of the SFRCs, Constr. Build. Mater. 41. 68–72(2013).

[12] Z. Xu, H. Hao, H.N. Li, Dynamic tensile behaviour of fibre reinforced concretewith spiral fibres, Mater. Des. 42. 72–88(2012).

[13] A.M. Alhozaimy, P. Soroushiad, F. Mirza,Mechanical properties ofpolypropylene fibre reinforced concrete and the effects of pozzolanicmaterials, Cement Concr. Compos. 18 (2) 85–92 (1996).

[14] M. Nili, V. Afroughsabet, The effect of silica fume and polypropylene fibres onthe impact resistance and mechanical properties of concrete, Constr. Build.Mater. 24 (6) 927–933(2010).

[15] K.C.G. Ong, M. Basheerkhan, P. Paramasivam, Resistance of fibre concrete slabsto low velocity projectile impact, Cement Concr. Compos. 21 (5) 391–401 (1999).

A. Badr, A.F. Ashour, A.K. PlattenStatistical variations in impact resistance ofpolypropylene fibre-reinforced concrete, Int. J. Impact Eng 32 (11) 1907–1920 (2006).

[16] K. Habel, P. Gauvreau, Response of ultra-high performance fibre reinforcedconcrete (UHPFRC) to impact and static loading, Cement Concr. Compos. 30(10) 938–946 (2008).

[17] J. Chen, N. Chouw, Compressive behaviour of flax FRP double tubeconfined coconut fibre reinforced concrete, Constr. Build. Mater. 112 666–673(2016).

[18] J. Chen, N. Chouw, Nonlinear flexural behaviour of flax FRP doubletube confined coconut fibre reinforced concrete, Mater. Des. 93 (247) 254(2016).

[19] X. Zhou, S.H. Ghaffar, W. Dong, O. Oladiran, M. Fan, Fracture and impactproperties of short discrete jute fibre-reinforced cementitious composites,Mater. Des. 49 (2) 35–47(2013).

[20] X. Wang, C. Zhang, Z. Huang, G. Chen, Impact experimental research on hybridbamboo fibre and steel fibre reinforced concrete, Appl. Mech. Mater. 357–3601049–1052 (2013).

[21] G. Ramakrishna, T. Sundararajan, Impact strength of a few natural fibrereinforced cement mortar slabs: a comparative study, Cement Concr. Compos.27 (5) 547–553 (2005).

[22] M. Ali, A. Liu, H. Sou, N. Chouw, Mechanical and dynamic properties of coconutfibre reinforced concrete, Constr. Build. Mater. 30 814–825 (2012).

[23] Standard A. C39/C39M-04. Standard test method for compressive strength ofcylindrical concrete specimens.

[24] Code CEBFIPM, Committee Euro-International du Beton, Bulletind'information213 214 (1993).

[25] P.H. Bischoff, S.H. Perry,Impact behaviour of plain concrete loaded in uniaxialcompression, J. Eng. Mech. 121 (6) 685–693(1995).

[26] M. Paja˛k, The influence of the strain rate on the strength of concrete takinginto account the experimental techniques, Archit. Civ. Eng. Environ. 3 77–86(2011).