A research project explored lightweight concrete using coconut shell and steel fibre through an experimental study.

Shubham Sagar
Student 1st, Civil Engineering Department
Buddha Institute of Technology
Gorakhpur U.P. India
bit21cel17@bit.ac.in

Vishal Singh
Student 2nd, Civil Engineering Department
Buddha Institute of Technology
Gorakhpur U.P. India
bit21cel25@bit.ac.in

Shishir Pratap Singh
Student 3rd, Civil Engineering Department
Buddha Institute of Technology
Gorakhpur U.P. India
bit21cel28@bit.ac.in

Prabhakant tripathi
Student 4th, Civil Engineering Department
Buddha Institute of Technology
Gorakhpur U.P. India
bit21cel45@bit.ac.in

Baijnath Nishad
Assistant Professor 5th, Civil Engineering Department,
Buddha Institute of Technology
Gorakhpur U.P. India
baijnath382@bit.ac.in

***Abstract*—This project aims to conduct an experimental investigation on M25 concrete using water cement ratio of 0.42. The study involves the addition of coconut shell aggregate in varying percentages (0%, 5%, 10%, 15%, and 20%) to assess its effectiveness in the concrete. Additionally, a perpetual rate of steel fibre is mixed in concrete which volume is 0.5%. we have tried to find density of M25 ratio concrete with quantity of steel fibre 0.5% and also find strength of split tensile and compressive for 7 days & 28 days. This experiment will be obtained by replacing the coarse aggregate to coconut shell and some quantity of steel fibres. The obtained results will be compared with those of standard concrete to evaluate the performance.**

Keywords- *Characteristics of concrete mixed, Reduced cost, Waste material, Lightweight concrete*.

1. Introduction

Nowadays there is a great demand for lightweight concrete in the construction industry and we cannot ignore it. Lightweight concrete is the only solution that decrease the density without affecting the strength of concrete. An effective way to achieve this is to include a new aggregate in the mix design. LWC is known for its capacity to use recycled waste materials as aggregates, which contributes to environmental sustainability and economic success. This not only reduce the overall weight of concrete but it also encourages the use of waste material as an aggregate which is cost saving and sustainable for construction. The use of lightweight concrete blocks has gained popularity in the construction industry due to its various applications. One of the key advantages of using lightweight concrete is the reduction in the overall weight of the structure. This not only enhances the structural efficiency but also contributes to cost savings during construction. Additionally, the utilization of alternative materials as a replacement for coarse aggregates helps in conserving natural resources, making it an environmentally sustainable choice. The addition of steel fibres in LWC plays a crucial role in enhancing its compressive and tensile strength. It is act as reinforcement in the concrete and providing strength to resist the cracking.

This reinforcement mechanism helps to distribute the applied load more evenly throughout the structure, thereby improving its overall strength and durability. The addition of steel fibre to lightweight concrete serves to augment in flexural strength, rendering it a suitable material for application that necessitate availability to resist bending force.

1.1 Objective of the study

- Investigating the basic characteristics of concrete mixed with coconut shell through the analysis of density, strength of split tensile and strength of compressive is the primary focus of this study.
- The ultimate goal of this research is to promote the utilization of these discarded materials as viable construction resources for affordable housing projects.
- One of the primary objectives of utilizing lightweight concrete (LWC) of building construction to minimize the overall concrete structure weight. This objective is particularly advantageous in high-rise construction, where the weight of the building materials can significantly impact the structural requirements of the building. By incorporating lightweight concrete in construction, builders can reduce the load on the foundation and support elements, resulting in lower construction costs and increased flexibility in design options. Therefore, lightweight concrete is an ideal building material for high-rise construction, where minimizing the weight of the building materials is a crucial consideration.
- Another crucial advantage of incorporating lightweight concrete in building construction is its ability to enhance the thermal and acoustic insulation properties of the building material. This is achieved by adding lightweight aggregates into the concrete mixture, which creates small air pockets within the material. These air voids help to reduce the transfer of heat and sound through the structure, resulting in a more comfortable and energy-efficient building with lower heating and cooling costs. In summary, utilizing lightweight concrete in construction can lead to a building that provides superior insulation, reduces energy consumption and costs, and enhances the overall comfort of the building occupants. Therefore, if you are looking for a construction material that can help you save on energy costs, enhance insulation, and improve the comfort of your building, lightweight concrete is an excellent choice.
- The cost-effectiveness of lightweight concrete is an important aspect of its development and use in construction. The utilization of lightweight aggregates in the concrete mixture is generally more economical than traditional aggregates, resulting in a reduced overall cost of construction. Moreover, the reduced weight of the concrete can lead to lower transportation and handling expenses, as well as fewer labour requirements during the construction process. Summarily, incorporating lightweight concrete in construction can result in a more cost-effective construction project with fewer expenses on materials, transportation, and labour. Therefore, if you are looking for a building material that can help you save on construction costs without compromising the quality of the materials, lightweight concrete is an excellent option to consider.

1.2 Scope of study

This study has the potential to revolutionize the concrete industry by comprehensively assessing the impact of incorporating coconut shell and steel fibre in light weight concrete. By evaluating properties such as strength, durability, and sustainability, we can identify the benefits of utilizing these materials in construction. Critical to the success of this study is the selection of appropriate materials for the concrete mix. We have meticulously planned the experimental setup and data collection processes to ensure accurate results. The insights gained from this study will benefit the industry by introducing new, sustainable materials that can enhance the performance of light weight concrete.

In addition to its uses in construction, lightweight concrete also has applications in infrastructure projects, such as the construction of roadways, tunnels, and retaining walls. Its lower weight can help to reduce the overall load on the underlying soil, making it an attractive option for these types of projects. Additionally, the thermal and acoustic insulation properties of lightweight concrete make it a viable option for the construction of noise barriers and sound walls along roadways and highways.

Indeed, the advancements in lightweight concrete technology are truly remarkable. The use of lightweight aggregates like expanded glass or plastic beads not only reduces the weight of the concrete but also enhances its insulation properties. This makes it an excellent choice for construction projects where weight and insulation are critical factors.

Over the last few years, the use of coconut shells in concrete has become popular due to its wealth, low cost and simple properties The material's workability, density and thermal conductivity have been found to be sustainable when coconut shells are partially replaced with coarse aggregate.

Additionally, the use of coconut shells in concrete production promotes the recycling of agricultural waste, contributing to environmental sustainability and reducing the depletion of natural resources.

The lightweight and insulating properties of coconut shells make them an attractive option for the construction of low-rise buildings, pavements, and non-structural elements.

2. MATERIALS AND METHODS

2.1 Coconut Shell Aggregate

Coconut shells, a plentiful waste material, can serve as a valuable alternative in construction. These shells, which pass through a 20mm IS sieve and are retained on a 12.5mm IS sieve. These are soaked in water for find water absorption and its time 24 hours. Due to their higher water absorption compared to coarse aggregate, they can be effectively utilized in concrete. Adding coconut shell mixture to the concrete mixture creates a building material that is both lighter and environmentally beneficial. This approach is parallel to the transition to a construction approach that emphasizes sustainability and environmental awareness on a global scale.

TABLE NO.1 COCONUT SHELL AGGREGATES PROPERTIES

Sr. No.	Characteristics	Result
1	Specific Gravity	1.41
2	Water Absorption (%)	17.6

2.2 Cement

Cement is an excellent material with additives and aggregates that provide a cohesive medium for the individual components. Cement is an extremely fine product that comes from the production of clinker produced by the first blasting of raw materials. The calcium and magnesium content of the stone should be as low as possible. Cement typically consists of 35% lime, 40% to 50% alumina, and up to 15% of iron oxide with less than 6% of silica. Calcium aluminate is the main bonding compound.

Upon mixing cement with water, it transforms into a paste that solidifies and binds aggregates (both fine and coarse) to create concrete. Its versatility lies in its ability to bind various materials together in construction projects, offering adhesive and cohesive properties that create a binding medium for different components. Cement enables varied designs and architectural construction of both small and large projects.

TABLE NO. 2 CEMENT’S PROPERTIES

Sr. No.	Characteristics	Results
1	Initial Setting Time	30 (minutes)
2	Final Setting Time	600 (minutes)
3	Consistency	31%
4	Fineness Modulus	7%

5	Specific Gravity	3.12

2.3 Fine Aggregate

The most important ingredients in concrete, fine aggregate, is what makes the building material better overall. This finely ground aggregate, which is less than 4.75 mm in size, is made from recycled concrete, crushed stone, or sand. Its main objective is to close the voids in the concrete mixture, which produces a perfect finish and improved workability. Fine aggregate is added to concrete to increase its durability and aesthetic appeal, resulting in a construction that is both long-lasting and attractive.

TABLE NO. 3 FINE AGGREGTAE PROPERTIES

Sr. No.	Characteristics	Results
1	Fineness Modulus	3.84 %
2	Specific Gravity	2.62
3	Water Absorption	0.815 %

2.4 Coarse Aggregate

Coarse aggregate, like crushed stone or gravel, strengthens and prolongs the life of concrete. When mixed with fine aggregate and cement, it fills gaps and boosts strength. Sourced from nature or recycled materials, it is graded by size for consistent concrete. Choosing the right coarse aggregate is vital for successful construction.

TABLE NO. 4 COARSE AGGREGATE PROPERTIES

Sr. No.	Characteristics	Result
1	Specific Gravity	2.80
2	Water Absorption (%)	0.512

2.5 Steel Fibre

Steel fibres, small pieces of steel, are added to concrete mixes to improve their mechanical properties and overall performance. Usually made from carbon or stainless steel, these fibres come in different shapes like hooked, crimped, or straight, depending on the intended use.

2.6 Methodology

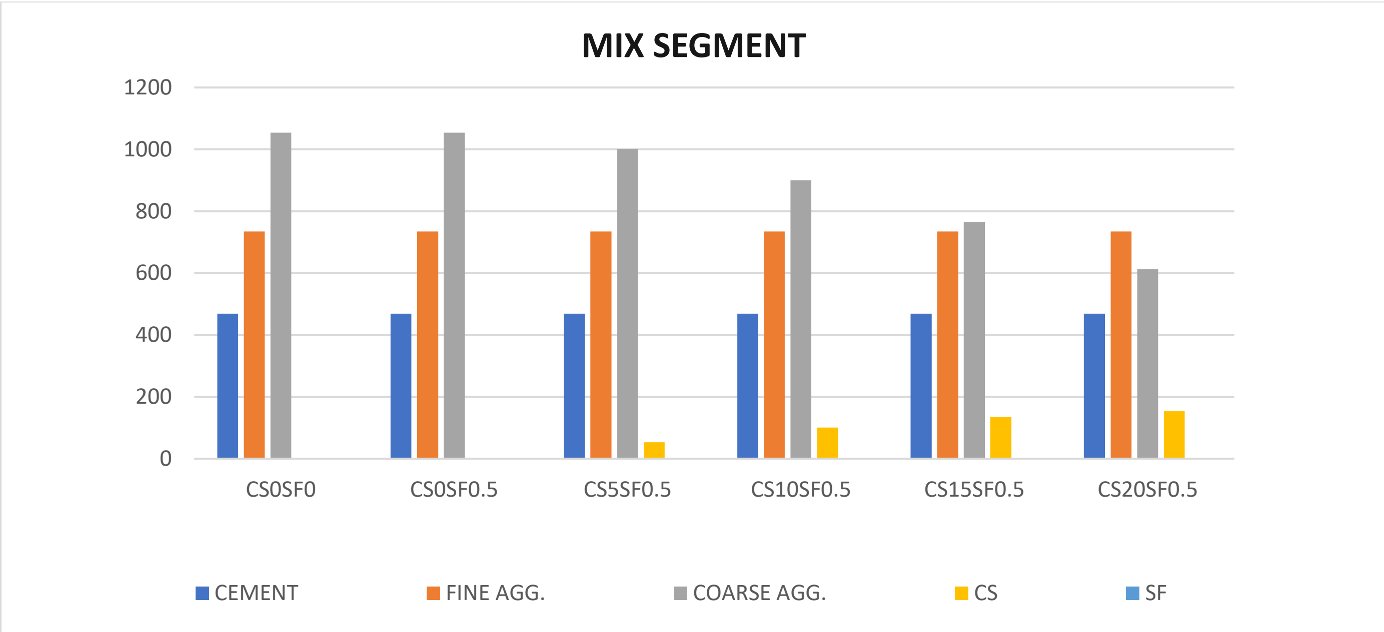
The composition of M25 concrete consists of cement, sand, and aggregate in a ratio of 1:1.5:2.2. In order to investigate the effects of coconut shells and steel fiber on the concrete, the natural coarse aggregate was replaced with varying percentages of coconut shells (0%, 5%, 10%, 15%, and 20%) and 0.5% steel fiber by volume of concrete. The accurate measurement of the weight of materials was achieved using a weighing machine. Each mixture contained cement, sand, aggregate, coconut shell, and stell fiber in the specified proportions. The concrete was thoroughly mixed in a tray to ensure uniformity.

To prepare the specimens, all the materials including cement (PPC), sand, aggregate, water, coconut shell, and steel fiber were gently filled into a cube and compacted using a tamping rod. For each proportion, three cubes of size 150mm×150mm×150mm were prepared and tested for compressive strength at 7 and 28 days. Additionally, three cylinders of size 150mm diameter and 300mm length were prepared for each proportion and tested for split tensile strength at 7 and 28 days. The specimens were kept undisturbed for 24 hours before being remoulded and immersed in a curing tank filled with water. The curing process lasted for 7 days.

Overall, this experimental setup allowed for the evaluation of the mechanical properties of the concrete samples under different proportions of coconut shells and steel fiber, while maintaining a constant water-cement ratio of 0.42 for all the samples.

TABLE NO. 5 MIX PROPORTIONS

Mix Segment	Cement (kg/m3)	Fine Agg. (kg/m3)	Coarse Agg. (kg/m3)	CS (kg/m3)	SF (kg/m3)
CS_0SF_0	469	735	1054	0	0
$CS_0SF_{0.5}$	469	735	1054	0	0.5
$CS_5SF_{0.5}$	469	735	1001	53	0.5
$CS_{10}SF_{0.5}$	469	735	900	101	0.5
$CS_{15}SF_{0.5}$	469	735	765	135	0.5
$CS_{20}SF_{0.5}$	469	735	612	153	0.5



3. RESULTS AND INVESTIGATION

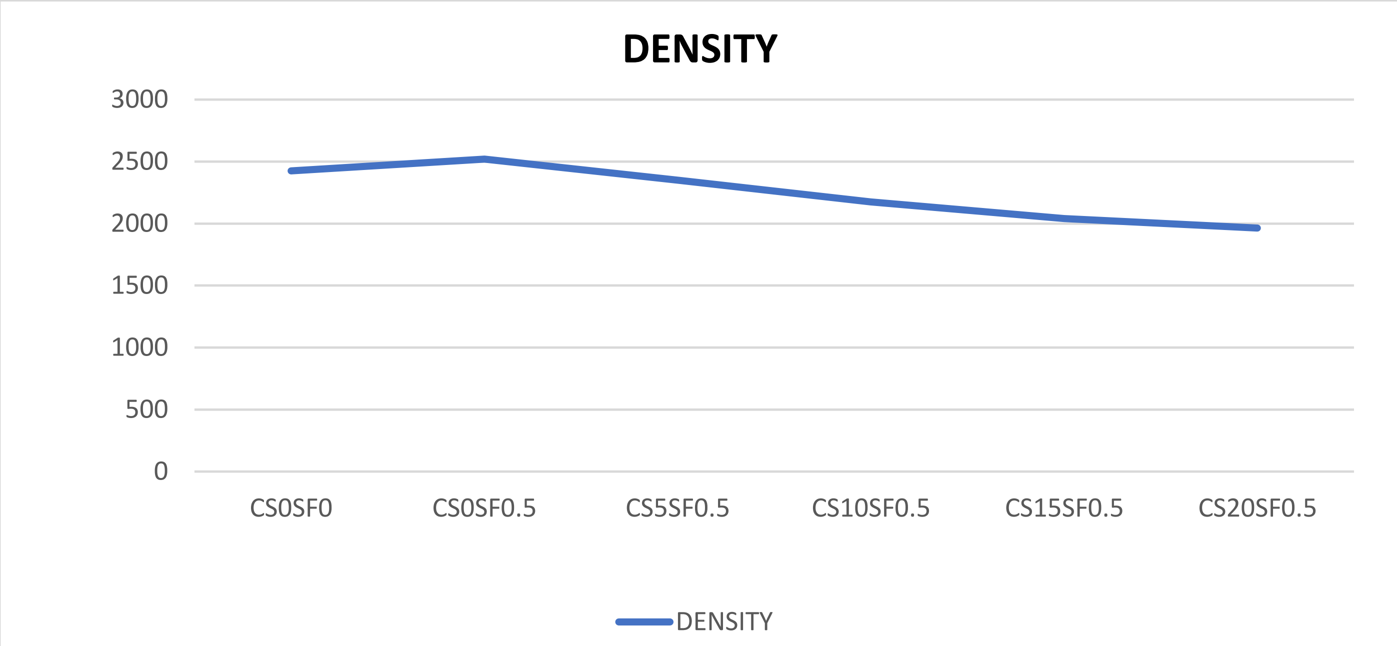
3.1 Results of experiments

3.1.1 Density

Density is the mass per unit volume of a solid substance. Density is calculated using the formula d = M/V, where d is density, M is mass, and V is volume.

TABLE NO. 6 DENSITY OF CONCRETE

SR. No.	Mix Segment	Weight (kg)	Volume (m^3)	Density (Kg/m^3)
1	CS_0SF_0	7.90	0.003375	2340
2	$CS_0SF_{0.5}$	8.54	0.003375	2530
3	$CS_5SF_{0.5}$	7.92	0.003375	2346
4	$CS_{10}SF_{0.5}$	7.33	0.003375	2171
5	$CS_{15}SF_{0.5}$	6.89	0.003375	2041
6	$CS_{20}SF_{0.5}$	6.64	0.003375	1967

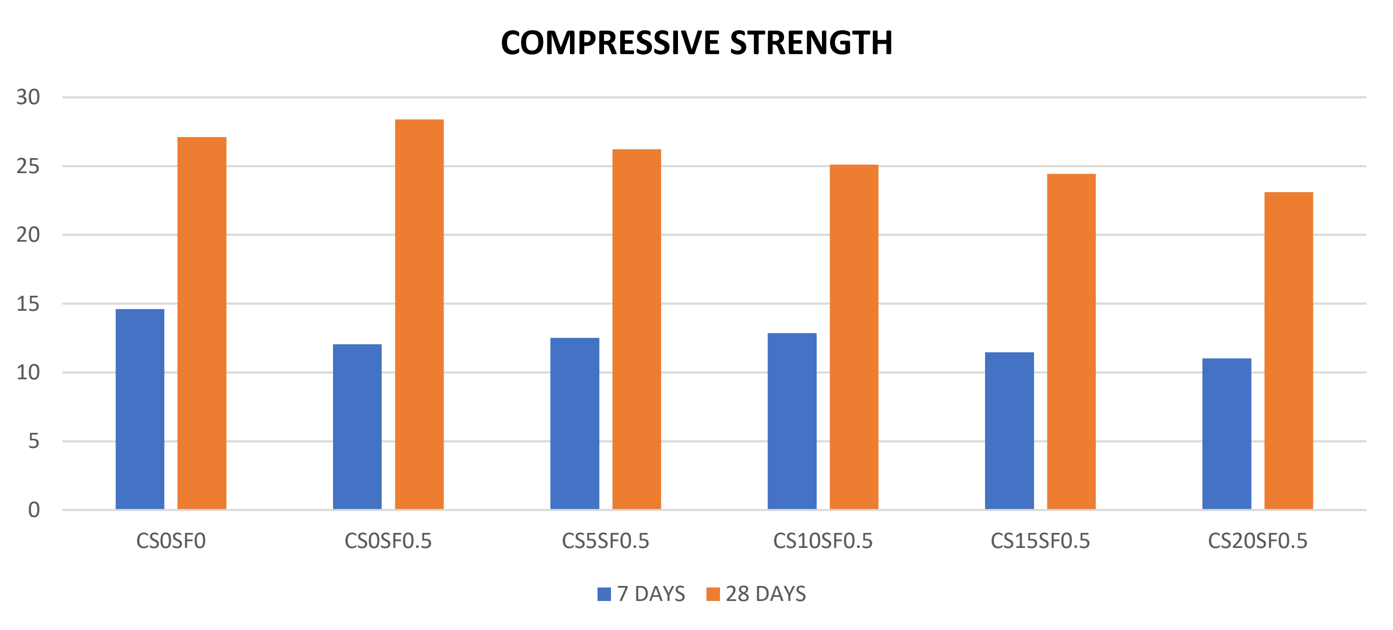


3.1.2 Compressive Strength

Compressive strength refers to the ability of concrete to withstand axial loading. It is determined through the utilization of a Compressive Testing Machine (C.T.M), where readings are taken until the point of ultimate crack formation. The primary function of a compressive strength machine is to apply a controlled and increasing compressive load to a material sample until it breaks or reaches a predetermined deformation point.

TABLE NO. 7 COMPRESSIVE STRENGTH

Sr. No.	Mix Segment	At 7 days(N/mm^2)	At 28 days(N/mm^2)
1.	CS_0SF_0	13.95	27.11
2.	$CS_0SF_{0.5}$	11.40	28.40
3.	$CS_5SF_{0.5}$	11.85	26.22
4.	$CS_{10}SF_{0.5}$	12.02	25.11
5.	$CS_{15}SF_{0.5}$	10.81	24.44
6.	$CS_{20}SF_{0.5}$	10.36	23.11



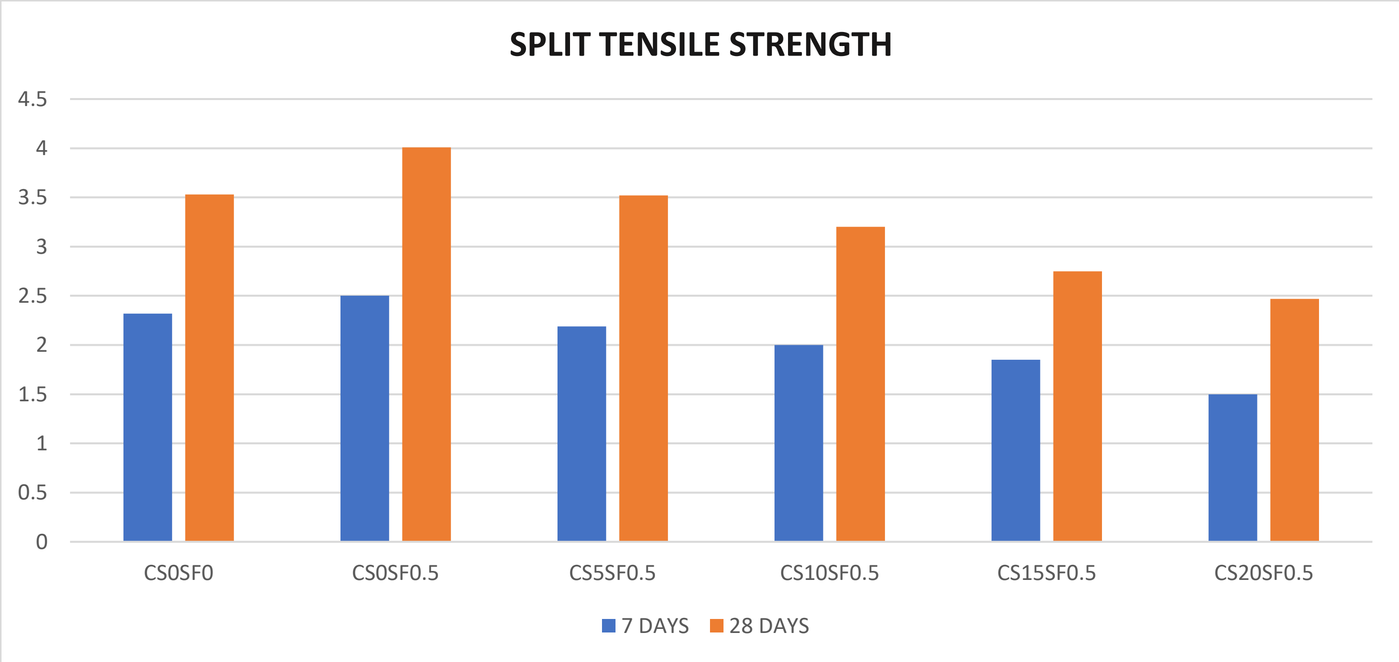
3.1.3 Split Tensile Strength

Split tensile strength is a critical mechanical property of concrete that provides valuable insights into its performance under tensile loading conditions. Unlike compressive strength, which measures a material's ability to withstand axial forces, split tensile strength assesses its resistance to tensile stresses applied perpendicular to the direction of loading.

This property is particularly important in evaluating the behaviour of concrete elements subjected to flexural or bending forces, such as beams, slabs, and pavements. A comprehensive understanding of split tensile strength necessitates an exploration of its underlying principles, testing methodologies, influencing factors, and practical significance in concrete engineering.

TABLE NO. 8 SPLIT TENSILE STRENGTH

Sr. No.	Mix Segment	At 7days (N/mm^2)	At 28days (N/mm^2)
1	CS_0SF_0	2.32	3.53
2	$CS_0SF_{0.5}$	2.50	4.01
3	$CS_5SF_{0.5}$	2.19	3.52
4	$CS_{10}SF_{0.5}$	2.00	3.20
5	$CS_{15}SF_{0.5}$	1.85	2.75
6	$CS_{20}SF_{0.5}$	1.50	2.47



CONCLUSIONS

Coconut shells have the potential to serve as a substitute for coarse aggregate, with replacement percentages ranging from 0% to 20%. However, it has been observed that a decrease in strength occurs when the replacement percentage exceeds 10%. Therefore, for optimal outcomes, it is recommended to limit the replacement of coconut shells to 10%.

In the realm of concrete technology, an innovative approach has been explored where dry concrete's density ranges from 2340 kg/m^3 to 1967 kg/m^3, thus achieving the characteristics of lightweight concrete. This is accomplished by substituting 10% of the aggregate, traditionally used in concrete, with coconut shell (use as an aggregate) and enhancing it with an additional 0.5% quantity of steel fibre. This modification allows the concrete to meet the minimum requirement for 28-day compressive strength.

Interestingly, the highest value for strength of split tensile was observed when no coconut shell was used, but a 0.5% addition of steel fibre was incorporated. When compared to conventional concrete, the result of compressive strength and strength of split tensile showed only a marginal reduction, even with up to 10% replacement of the aggregate with coconut shell and the inclusion 0.5% of steel fibre.

This innovative material has potential applications in various building components such as ground floor slabs, sunshades, lofts, kitchen countertops, and cupboard slabs. It presents an effective strategy for employ waste materials that are produced in substantial quantities.

REFERENCES

1) Vishwas P. Kukarni and Sanjay Kumar Gaikwad 2013, Comparative study on coconut shell aggregate with conventional concrete International Journal of Engineering and Innovative Technology 2 67-70.

2) Song P S and Hwang S 2004, Mechanical properties of high-strength steel fibre-reinforced concrete Journal of Construction and Building Materials 18 669–673.

3) Xin Luo, Wei Sun and Sammy Y.N Chan 2000, Characteristics of high-performance steel fibre reinforced concrete subject to high velocity impact Journal of Cement and Concrete Research 30 907-914.

4) Pravin V. Khandve, Shrikant M. Harle "Coconut Shell as partial replacement of coarse aggregate in concrete review" International Journal of Pure and Applied Research in Engineering and Technology, Volume:2 (9), 2014.

5) Gunasekaran, K.; Annadurai, R.; Chandar, S.P.; Anandh, S. Study for the relevance of coconut shell aggregate concrete non pressure pipe. Ain Shams Eng. J. 2017, 8, 523–530. [Cross Ref]