COMPARISON ANALYSIS AND PERFORMANCE OF LIGHT WEIGHT AGGREGATE CONCRETE INTRODUCTION

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ABSTRACT: Cement concrete is a building material which consists of hard inorganic materials called aggregates such as fine aggregate (sand), and crushed rock, cemented together with Portland cement and water etc. In the last few years the construction industry is consuming very high natural resources for production of concrete due to rapid growth of industrialization. Due to the effect of this rapid utilization, the presence of natural resources will be a big question for future generations. To minimize the impact on nature, it is necessary to find alternate materials to produce concrete.

In the growing need for electricity in India, 70% of power is generated through thermal power plants. The environmental dreads from these plants include air pollution due to particulate Emission, water pollution and shortage of land for dumping the fly ash. Further, the poor quality of Indian coal has high ash content, which worsens the disposal problem.

INTRODCUTION

Lightweight concrete is a type of concrete that incorporates lightweight aggregates to reduce its density, making it lighter than traditional concrete. This type of concrete is advantageous in various applications where weight is a critical factor, such as in construction projects where structural load is a concern or in applications where insulation properties are important. Lightweight concrete typically has a density ranging from 1,600 to 1,900 kg/m³, which is significantly lower than the density of normal concrete (2,400 kg/m³).

Lightweight Aggregates

Lightweight aggregates are the key components that contribute to the reduced density of lightweight concrete. These aggregates can be classified into two main categories:

a) Natural Lightweight Aggregates

❖ **Expanded Shale, Clay, and Slate (ESCS):**
These aggregates are produced by heating and expanding natural shale, clay, or slate materials. The expansion process creates a porous structure, resulting in lightweight aggregates with good strength characteristics.

❖ **Pumice:**
Pumice is a volcanic rock that is lightweight due to the presence of air-filled voids. It is crushed and used as an aggregate in lightweight concrete.

❖ **Perlite:**
Perlite is a volcanic glass that expands when heated. The expanded perlite is lightweight and is used as an aggregate to produce lightweight concrete.

b) Artificial Lightweight Aggregates

❖ **Expanded Clay Aggregate (LECA):**
This is produced by heating clay in a rotary kiln, causing it to expand. The resulting lightweight and porous material is crushed and used as an aggregate in lightweight concrete.

❖ **Expanded Glass Aggregate:**
Crushed recycled glass can be expanded to create lightweight aggregate with good insulating properties.

❖ **Expanded Polystyrene (EPS) Beads:**
EPS beads can be incorporated into concrete mixes to create lightweight concrete. These beads are lightweight and provide insulation properties.

Fly ash aggregate

Fly ash aggregate lightweight concrete is a type of concrete that incorporates fly ash as a primary ingredient in the form of lightweight aggregates. Fly ash is a byproduct of coal combustion in power plants, and its use in concrete not only provides a sustainable solution for waste disposal but also imparts desirable properties to the concrete.

In this concrete mix, traditional heavy aggregates like gravel or crushed stone are partially or entirely replaced with lightweight aggregates made from fly ash. These lightweight aggregates are typically produced by pelletizing or sintering fly ash particles, resulting in porous and lightweight structures. The incorporation of these aggregates significantly reduces the overall density of the concrete, making it lighter than traditional concrete while maintaining adequate strength.

Fly ash itself possesses pozzolanic properties, meaning it reacts with calcium hydroxide to form additional cementitious compounds. This enhances the strength and durability of the concrete. Furthermore, the use of fly ash in concrete contributes to a reduction in the carbon footprint of construction projects, as it utilizes a waste product that might otherwise be disposed of in landfills.

The lightweight nature of fly ash aggregate lightweight concrete makes it particularly suitable for applications where weight is a critical factor, such as in the construction of high-rise buildings, bridges, and precast elements. Additionally, the insulation properties of lightweight concrete can contribute to energy efficiency in buildings by reducing the need for additional insulation materials. fly ash aggregate lightweight concrete is a sustainable and innovative construction material that not only utilizes a waste product but also offers a lightweight and durable alternative to traditional concrete, with potential benefits for both the environment and construction industry.

1.2.3 Coconut shell aggregate

Coconut shell aggregate lightweight concrete is a sustainable and environmentally friendly construction material that utilizes coconut shells as a partial replacement for traditional aggregates like gravel or crushed stone. This innovative approach not only addresses the growing concern of depleting natural resources but also offers a solution for the disposal of coconut shells, which are abundant in many tropical regions.

The lightweight nature of coconut shell aggregate concrete makes it particularly suitable for applications where reduced structural weight is essential. This includes construction projects where load-bearing capacity is a critical factor, such as in high-rise buildings, bridges, or structures with poor soil conditions. The low density of coconut shell aggregate concrete contributes to improved thermal insulation and energy efficiency, making it an attractive option for regions with extreme temperature variations.

In addition to its structural benefits, coconut shell aggregate concrete also possesses unique aesthetic qualities. The use of natural materials like coconut shells can impart a distinctive appearance to the finished product, adding a touch of organic beauty to architectural designs.

However, it's important to note that the use of coconut shell aggregate in concrete does come with challenges. The lightweight and porous nature of coconut shells can lead to a reduction in compressive strength compared to traditional concrete. Researchers and engineers are continuously exploring ways to optimize the mix proportions and enhance the mechanical properties of coconut shell aggregate concrete.

Coconut shell aggregate lightweight concrete represents a promising avenue for sustainable construction practices. By repurposing agricultural waste into a valuable construction material, it contributes to resource conservation, waste reduction, and the development of eco-friendly building solutions. Ongoing research and advancements in concrete technology will likely further refine the properties and applications of coconut shell aggregate concrete in the construction industry.

1.2.4 Advantages of Lightweight Concrete

Reduced Weight: The primary advantage is the reduced weight, making it suitable for applications where weight is a critical factor, such as in high-rise buildings.

Improved Insulation: Lightweight aggregates often have good insulating properties, making lightweight concrete a good choice for applications requiring thermal insulation.

Ease of Handling: Due to its reduced weight, lightweight concrete is easier to handle and transport.

Better Fire Resistance: Lightweight aggregates can contribute to better fire resistance properties.

1.2.5 Applications of Lightweight Concrete

1) Building Construction:

Lightweight concrete is used in the construction of residential and commercial buildings, especially in areas with seismic considerations.

2) Bridge Construction:

Lightweight concrete can be used in bridge construction to reduce dead loads.

3) Insulation:

Lightweight concrete is used for insulation in applications where both structural support and insulation properties are required.

4) Roof Decking:

It is commonly used in roof decking applications due to its lighter weight.

RESEARCH SIGNIFICANCE

The demand for lightweight aggregate has significantly increased as a result of the rise of construction activity. Ongoing research is currently focused on developing artificial aggregate from industrial by-products and waste materials due to the restricted availability of natural resources suitable for use as lightweight aggregate. There is an increasing focus on environmental concerns related to the use of industrial wastes, including coconut shell ash. Coal fly ash, derived from thermal power stations, is the most readily available type of industrial waste. Coconut shells can be readily obtained from agricultural fields. The conversion of fly ash into aggregate enables its widespread application in the construction industry. This study focuses on investigating the utilization of cold-bonded fly ash aggregates and coconut shell aggregates for the manufacturing of lightweight concrete.

SCOPE OF THIS STUDY

- Applicability in situations where lightweight structures are desired to reduce dead loads, such as in precast elements, high-rise buildings, and certain infrastructure projects.
- Suitable for applications where insulation is required, such as in residential buildings or structures exposed to temperature variations.
- Utilized in structural elements where strength requirements are moderate, such as in non-load-bearing walls, partitions, and slabs.
- Applicable in situations where transportation and installation constraints necessitate lightweight materials, such as in remote locations or on sites with limited equipment.

OBJECTIVE OF THIS STUDY

✓ To develop an alternative coarse aggregate by combining fly ash with coconut shell, resulting in the development of a lightweight aggregate.

✓ To create an optimal mix design for concrete using alternate coarse

✓ aggregates.

✓ To determine the workability properties of concrete containing alternative coarse aggregates.

✓ To compare the strength and durability properties of concrete made with different coarse aggregates to those of ordinary concrete.

METHODOLOGY OF PRESENT WORK

The methodology for each and every stage of the work is depicted in Figure 1.1.

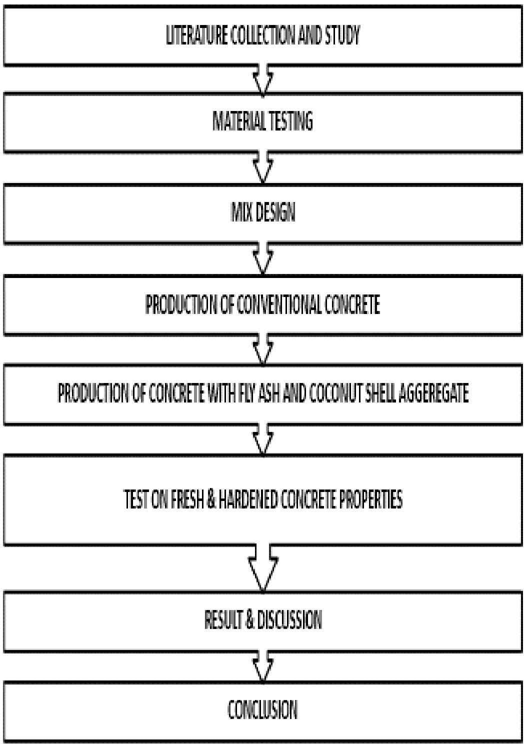

Figure 1.1 Methodology of present research work

LITERATURE REVIEW

GENERAL

In this chapter, literature on fly ash aggregate and coconut shell aggregate utilization in concrete, mechanical properties of fly ash aggregate artificial aggregates, durability studies of fly ash aggregate artificial aggregate concrete, are reviewed and presented.

Nusret Bozkurt *et al.* (2010) conducted an experimental investigation to determine the effect of pozzolanic materials and curing regions on the mechanical properties and capillary water absorption (Sorptivity) characteristics of light weight concrete. The results indicated a strong association between concrete & its strength development and its sorptivity. Compressive and tensile strengths

increased greatly as a result of hydration, but sorptivity coefficients reduced dramatically.
Josef Hadi Pramana *et al*. (2010) have shown that light-weight concrete can be used to replace conventional concrete in structure shields. As an energy absorber, aerated concrete and low-weight aggregate concrete can be employed. The high energy absorption capacity of aerated concrete is attributable to the homogenised microstructure of the component and the entrapment of air voids in the cement, depending on the materials used. The addition of light weight material to concrete strengthens it, preventing localised damage caused by ballistic loading. Lightweight concrete with a lower modulus of elasticity and greater tensile strain capacity resists impacts better than conventional concrete. Rajamane et al. (2004) proved that coarse aggregates can be produced from fly ash using palletisation techniques for use in structural grade concrete. Additionally, they investigated bulk density, specific gravity, water absorption, and aggregate crushing value. The concrete made with bonded fly ash coarse aggregate has a high slump, a low density, and also meets the IS 456-2000 requirement for minimum structural grade concrete. Permeability tests such as sorptivity, water absorption rate, and rapid chloride permeability test, among others, indicate satisfactory durability characteristics.Carlos Videla *et al.* (2001) demonstrated that agglomerating fly ash using agitation methods with a disc pelletizer is a simple and effective process for manufacturing aggregates. Paste mixtures agglomerated with cement binders have a fivefold reduction in setting times compared to paste mixtures agglomerated with lime. The aggregates made with 5% Portland pozzolanic cement have the greatest viability for use in large-scale production.Diana Bajare *et al*. (2013) have studied the production of light weight concrete with the help of aggregates made by industrial by-products and hazardous solid waste namely expanded fly ash, slag, sludge etc. The literature elucidated the potentials to reuse waste known as Non-Metallic Product (NMP) from aluminium scrap recycling factories for the developed of lightweight expanded clay groups and light weight concrete. The industrialized cycle of light weight expanded clay combinations were replicated in laboratory using sintering the clay waste mixes in the rotary furnace up to 1200°C. Light weight prolonged clay sums with rather dissimilar pore edifice were attained because of slight differences of mixture composition and sintering temperature. Fashioned totals were with bulk density from 320 kg/m ^{3} to 620 kg/m^3.
Gang Zheng *et al.* (2011), have investigated the high-speed railway were built between two major cities in China. Then part of the railway is over soft marine clay, appropriate ground development, cement-fly ash-gravel piles, was selected to progress the soft marine clay to meet technical necessities for the high-speed railway. The literature clarified the field measurements in the railway embankment project including the load distribution between soils and piles, excess pore pressure, and settlement and lateral displacement. The test results showed that the stress concentration to the piles reduced the excess pore pressure effectively. The proportion of the load carried by soils was small, and therefore the settlement had considerably reduced. To less than 21% of the total settlement, the compression of the rigid piles contributed. Calaveri *et al*. (2003) shown that pumice aggregate is not inferior to natural granite aggregate when loading testing on structural systems composed of LWPSC are considered. M.N. Haque *et al*. (2004) conducted tests on the Strength and durability of lightweight concrete. The results indicated that the water penetrability and carbonation depth of SLWC are nearly equivalent to those of comparable strength and much less than those prepared with both fine and coarse LWA. Harikrishnan, K.I., and Ramamurthy., 2006, investigated the production of fly ash pellets. They concluded that the efficiency of pellet production is determined by the speed of the pelletizer disc& 39; s revolution, the moisture content, the angle of the pelletizer disc, and the duration of pelletization. According to Raghuprasad et al. (2009) rapid industrialization has increased pollution levels and the scarcity of naturally available materials. As a result, it is necessary to investigate alternatives to conventional aggregate, and one possible method is to replace conventional aggregate with cinder. Several laboratory trials were carried out to investigate the possibility of using pelletized cold bonded light weight aggregate as a replacement for natural coarse aggregates in concrete. Ming *et al.* (2014) investigated the effects of coarse OPS aggregates in high strength lightweight concrete. In this work, heat treatment is applied to OPS coarse aggregates. The results of the tests revealed that the workability of the OPS coarse aggregate increases as the temperature rises. The compressive strength of the concrete was noted to be significant. Furthermore, the ultrasonic pulse velocity is investigated, and the results show that the oil palm shell highstrength lightweight concrete is in good condition.

Niyazi *et al.* (2011) investigated the effect of sintered lightweight fly ash aggregates, cold-bonded lightweight fly ash aggregate, and normal weight crushed limestone aggregate on the strength and elastic properties of concrete mixtures. Different models were also developed to predict the strength and modulus of elasticity of concretes. The outcome demonstrates the success inproducing high-strength air-entrained lightweight aggregate concretes using sintered and cold-bonded fly ash aggregates. To achieve the desired slump and air content, lightweight concretes used fewer chemical admixtures than normal- weight concrete, resulting in lower production costs. According to this study,using lightweight aggregates instead of normal weight aggregates in concrete production reduced the strength slightly.

Shannag *et al*. (2011) investigated the properties of concrete using locally available natural lightweight aggregates and mineral admixtures. For this study, they used silica fume and fly ash to replace cement in structural light weight concrete. Experiment results showed that replacing cement with silica fume up to 15% in light weight concrete increased compressive strength by 57% and modulus of elasticity by 14% when compared to control concrete. Adding up to 10% fly ash as a partial replacement of cement in the same mix results in an 18% decrease in compressive strength with no change in modulus of elasticity compared to control concrete. As a result, the author proposed that adding 10% or more silica fume and 5% or more fly ash to lightweight concrete mixes performs better in terms of strength and stiffness than individual mixes prepared with the same contents of silica fume or fly ash.

Bing *et al*. (2008) studied the impacts of mineral admixtures such as Fly Ash (FA), Blast Furnace Slag (BS), and Silica Fume (SF) on workable high strength lightweight concrete. The results showed that both Blast Furnace Slag and Silica Fume could effectively improve the bonding of the mixtures, and thus the concrete strength at both early and late ages. According to the paper, fly ash improves the workability of the mixture while bleeding reduces its homogeneity. The combination of fly ash and blast furnace slag produces the best high-strength lightweight concrete with good workability and strength.

Verma *et al*. (2019) Compressive strength of coconut shell concrete has been evaluated on 7, 14, 21 and 28 days. The compressive strength of coconut shell concrete was reduced as percentage replacement increased. Concrete mixtures were tested and compared in terms of compressive strength of the conventional concrete. The study result shows that Coconut Shell Concrete (CSC) can be used as light weight concrete. Use of Coconut Shell as a substitute of aggregate will not only is cost effective and eco friendly, but also help to resolve the problem of shortage of conventional material such as coarse aggregate. Use of such materials also reduces the problem of disposal of waste material

Janani *et al.* (2022) investigated the assessment of coconut shell's effectiveness as a coarse aggregate in concrete. Lightweight Concrete (LWC) is commonly compressed using waste materials as aggregates to achieve economic improvement. Coconut Shell Concrete (CSC) has superior impact resistance compared to conventional concrete (CC). The CSC can also be used for constructing partition walls. Using CS in concrete seems to be a feasible option. Due to their biodegradability and natural abundance, CS can be conveniently utilized in concrete. This work presents a thorough examination of the mechanical characteristics of concrete while using CS as the coarse aggregate. The primary objective of this study is to provide a comprehensive perspective on the utilization of CS as a coarse aggregate. The review focused on the durability qualities and elasticity modulus of concrete when using CS as a coarse aggregate.

Jerin *et al.* (2016) examined the characteristics of concrete when crushed coconut shell is used as the coarse aggregate. The coarse aggregate was substituted with crushed coconut shells at three distinct proportions: 25%, 50%, and 100%. The workability, compressive strength, flexural strength, and splitting tensile strength of the aforementioned mixtures were compared to the qualities of regular concrete. The study's findings are anticipated to encourage the utilization of coconut shell as an alternative to traditional coarse aggregates.

The study conducted by Yashida *et al.* in 2017 A study was conducted to examine the durability characteristics of concrete made with Coconut Shell (CS) aggregate. The impact of mineral admixtures, such as fly ash and ground granulated blast furnace slag (GGBFS), on the durability qualities of CS aggregate concrete when used as a partial replacement for cement was also confirmed. The study examined four different concrete mixes. The experimental mixtures consist of a control mix, a mix in which 18.5% of the coarse aggregate is replaced by CS (by weight), a mix in which 18.5% of CS and 30% of cement are replaced by fly ash, and a mix in which 18.5% of CS and 15% of cement are replaced by GGBFS.

Lucyna (2020) experimented on the durability of lightweight concrete containing sintered fly ash aggregates. Twelve different concrete mixes were made with different water cement ratio (0.55 or 0.37), coarse aggregate gradation (4/8 mm or 6/12 mm) and initial moisture condition of coarse aggregates (oven dried, moistened or water saturated). The density of all the concrete mixes were within 1470 kg/m^3 and 1920 kg/m^3. The water absorption of the concrete was indicated by their densities as it represents the porosity of aggregate and cement matrix. More the density of concrete, lesser was the water absorption of the concrete. The concrete produced with pre saturated aggregates were less durable when compared with the concrete containing dried or moistened aggregates.

Amarnath *et al*. (2017) Properties of concrete with coconut shells (CS) as aggregate replacement were studied. Control concrete with normal aggregate and CS concrete with 10 - 20% coarse aggregate replacement with CS were made. Two mixes with CS and fly ash were also made to investigate fly ash effect on CS replaced concretes. Constant water to cementitious ratio of 0.6 was maintained for all the concretes. Properties like compressive strength, split tensile strength, water absorption and moisture migration were investigated in the laboratory.

Dodda Nagarjun *et al.* (2017) The high cost of conventional building materials is a major factor affecting housing delivery in world. This has necessitude research into alternative materials of construction and analyzing flexural and compressive strength characteristics of concrete produced using crushed and sieved, granular coconut as substitute for conventional coarse aggregate with full replacement using M20 grade concrete.

Yogesh *et al.* (2013) The paper analyzed compressive strength of concrete (M20-1:1.5:3) produced using coconut shell as substitute for conventional coarse aggregate with 0%, 25%, 50%, 100% partial replacement. Three sample cubes are prepared for M20 grade concrete mix for each case another aim of this paper is to spread awareness about use of coconut shell as construction material in civil engineering.

Robert *et al. (*2017) Coconut Shell Concrete (CSC) could be used in rural areas and places where coconut is abundant and may also be used where the conventional aggregates are costly. And also adding a steel fibre of certain amount for increasing the strength in concrete and by improve its crack resistance, ductility, energy absorption and impact resistance characteristics. An attempt has been made to examine the suitability of partial replacing 10%, 20% and 30% of coconut shell as for coarse aggregate in concrete of grade M20 and also adding a steel fiber at a certain amount in the concrete. The results found were comparable with that of conventional mix.

Kayali O (2008) experimented on the properties of with different coarse aggregates. The coarse aggregates used in the study were granite, dacite, commercially available pelletized fly ash aggregates (SP) and artificially manufactured fly ash aggregates made using fly ash (FAA). Four different concrete mixes were made using above specified coarse aggregates.

The concrete with commercial fly ash pellets was designated as SP concrete and the concrete with artificial fly ash aggregates was designated as FAA concrete. The workability test was performed on all the four concrete mixes using slump cone. The slump of SP and FAA concrete was comparatively higher than the slump of concrete containing granite and dacite aggregates. The use of fly ash aggregates reduced the density of concrete.

A review by Saad and Kumar (2019) Utilizing agricultural detritus in cement, concrete, and other construction materials provides numerous indirect benefits, including energy conservation, environmental protection, and a reduction in landfill expenses. The objective is to achieve cost-effective concrete production while simultaneously upholding environmental sustainability standards.

The primary emphasis of this review paper will be on the utilization of coconut shell as coarse aggregate in construction-grade concrete. Shells of coconuts are suitable for use as aggregates in concrete. Coconut shell concrete is distinguished by its workability, flexural tensile strength, compressive strength, and split tensile strength, among other qualities. The objective of this study is to determine whether coconut shell is the most suitable material to incorporate into lightweight concrete.

2.2 SUMMARY FROM LITERATURE

Literature studies on the use of coconut shell aggregate and fly ash aggregate in construction materials revealed significant insights into sustainable and eco-friendly alternatives for traditional aggregates. Coconut shell aggregate, derived from agricultural waste, offers a lightweight and environmentally friendly option, contributing to the reduction of solid waste. Studies suggest that incorporating coconut shell aggregate into concrete enhances its thermal insulation properties and reduces overall material density. On the other hand, fly ash aggregate, a byproduct of coal combustion, demonstrates potential as a supplementary material for concrete production. Research indicates that fly ash aggregate can improve the durability and strength of concrete while mitigating the environmental impact associated with coal waste disposal. Both coconut shell and fly ash aggregates exemplify promising solutions for achieving sustainable construction practices, addressing concerns related to resource depletion and waste management in the building industry. Further investigations and real-world applications are essential to fully understand and optimize the performance of these alternative aggregates in various construction contexts.

MATRIALS AND METHODOLOGY

INTRODUCTION

This chapter describes the materials and methods used to examine the performance of light weight concrete. Lightweight concrete was created by combining fly ash aggregate (FA). The results of that experiment are presented in this study.

MATERIALS ARE USED IN THIS STUDY

Materials used in this research work and their properties are listed below

- 53 Grade Ordinary Portland cement
- Fly ash
- Coarse aggregate
- Fine aggregate
- Fly ash aggregate
- Coconut shell aggregate
- Water

Cement

Ordinary Portland cement of 53 grade, (Ultra tech cement) conforming to IS:12269-2013 was used for the present experimental investigation. The cement was tested as per the procedure given in Indian Standards IS: 4031 - 1988. Its specific gravity is 3.14. The physical properties and chemical composition of 53 grade cement are given in Tables 3.1 and 3.2.

Table 3.1 Physical properties of cement

S.No	Test Particulars	Test Value	Requirements of IS 8112-1989
1	Fineness (m^2/kg)	320	Minimum 225
2	Normal consistency (%)	26.4	-
3	Initial setting time (min)	135	Minimum 30
4	Final setting time (min)	325	Maximum 600
5	Soundness (mm)	1.00	Maximum 10
6	Specific gravity	3.15	-

Table 3.2 Chemical composition of cement

S.No.	Element present	Percentage
1	SiO_2	23.80
2	Al_2O_3	5.86
3	Fe_2O_3	5.47
4	CaO	63.30
5	Na_2O	0.71
6	K_2O	0.86

Natural Coarse Aggregate (NCA)

Locally available coarse aggregates having the maximum size of 10mm and20mm were used in the present work. Testing of coarse aggregates was done as per IS: 383-1970. The 10mm aggregates used were first sieved through 10mm sieve and then through 4.75mm sieve and 20mm aggregates were firstly sieved through 20mm sieve. They were then washed to remove dust and dirt and were dried to surface dry condition. The results of various tests conducted on coarse aggregate are listed in Table 3.3 and the sieve analysis of coarse aggregate is depicted in Table 3.4.

Table 3.3 Properties of Natural Coarse Aggregates

S.No	Characteristics	Value
1	Type	Crushed stone
2	Maximum size	20mm
3	Specific gravity	2.80
4	Total water absorption	0.80%
5	Fineness modulus	7.17
6	Bulk density	1568 kg/m^3

Table 3.4 Sieve analysis of 20mm aggregates

S.No	Sieve No.	Percentage Passing, (%)	Limit of IS 383: 2016
1	20 mm	100	85-100
2	16 mm	96.75	N/A
2	12.5 mm	38.56	N/A
3	10 mm	6.58	0-20
4	4.75 mm	0.7	0-5

Fine Aggregate

Natural river sand with fraction passing through 4.75 mm sieve and retained on 600 µm sieve was used and tested as per IS: 2386 - 1963. The physical properties and sieve analysis of fine aggregate are presented in Tables 3.5 and 3.6 and it conforms to grading zone II of IS: 383 - 2016.

Table 3.5 Properties of fine aggregates

S. No.	Properties	Test Value
1	Specific Gravity	2.60
2	Dry Density (kg/m^3)	1574
3	Fineness Modulus	2.15

Table 3.7 Physical properties of fly ash

S. No.	Properties	Obtained value
1	Specific Gravity	2.30
2	Dry Density (kg/m^3)	1070
3	Fineness Modulus	1.15

Table 3.6 Sieve analysis of fine aggregate

S.No	IS Sieve Size	% Passing
1	4.75 mm	100.00
2	2.36 mm	90.91
3	1.18 mm	67.74
4	600 µm	45.15
5	300 µm	15.30
6	150 µm	0.00

Fly Ash

Fly ash is one of the byproducts of combustion and consists of the fine particles carried upward by the flue gases. Typically, fly ash refers to the ash produced after the burning of coal in an industrial setting. Being a byproduct of thermal power plants, it is one of the most plentiful additional binding materials accessible. In the investigation, fly ash from the Mettur thermal power plant was employed, which included little calcium oxide; the molar ratio of Si to Al was 3, and SiO_2 dominated the composition. The physical and chemical parameters of fly ash are provided in Tables 3.7 and 3.8, respectively, and a sample of fly ash is depicted in Figure 3.1.

Figure 3.1 Sample of fly ash

Table 3.8 Chemical properties of fly ash

S.No.	Compound	Percentage
1	SiO_2	65.93
2	Al_2O_3	23.69
3	Fe_2O_3	2.82
4	CaO	3.93
5	Na_2O	0.86
6	K_2O	2.77

Water

In accordance with IS 456:2000, potable water is used in the preparation of fly ash aggregate, mixing of concrete, and curing of concrete.

Fly ash Aggregates

The fly ash aggregates were made with class F fly ash. This chapter contains all of the relevant details. Cold bonding technique was used to prepare fly ash aggregates through the pelletization process in a drum pelletizer.

Preparation of Fly ash Aggregates

Pelletization process

Grain size circulation is preferred for manufactured lightweight aggregates that are either crushed or agglomerated. When making lightweight coarse aggregate, the pelletization procedure is used; a few factors must be taken into consideration, such as how fast a circular motion is unwound and how much dampness is present in a pelletizer plate's edge. Plate or dish sort, drum sort, cone sort, and blender sort of pelletizer machine were used to create the pellets. When using a plate sort pelletizer, it is easier to control the flow of pellets than a drum sort pelletizer.

The disc pelletizer rotates at 35 to 55 revolutions per minute (rpm) while having a diameter of 570 millimetres and a side depth of 250 millimetres. It is housed in a flexible frame that allows it to be tilted between 35 and 55 degrees. In a cold-bonded process, the pellet's strength is increased by increasing the fly ash/cement ratio to 0.2 or higher. (by weight). Disc parameters like moisture content and disc angle affect pellet size growth. To make fly ash balls, the optimal binding agent dosage was found to be between 20% and 25% of the aggregate weight of binders.

Fly ash powder tends to form lumps when rotated without water in the disc, so additional water is sprayed on during the rotating process to ensure that the fly ash powder doesn't form lumps and that the particle size distribution is improved. The pellets are formed in about 20 minutes. Schematic view of disc pelletizer is illustrated in Figure 3.2.

Figure 3.2 Photographic view of disc pelletizer

Fly Ash Aggregates Proportions

Cement and fly ash, are used to prepare aggregates. Additionally, water acts as a binder, enhancing the workability. The cement and fly ash are mixed in a ratio of 30:70.

Processing and Curing of Fly Ash Aggregates

The prepared green pellets are allowed to dry for three days. Fly ash aggregates are then put for 7 days curing.

Segregation of Fly Ash Aggregates

Following curing, they were separated into fine and coarse aggregates according to pellet size, as illustrated in Figure 3.2. Aggregates of varying sizes Fine aggregates with a size less than 4.75 mm were sieved separately from coarse aggregates with a size greater than 4.75 mm. They were sieved to separate coarse aggregates with a diameter of 20 mm for use as coarse aggregates. Various tests are conducted on prepared fly ash aggregate and the physical properties of fly ash coarse aggregate (FCA) are listed in Table 3.9. Figure 3.3 depicted the sample of fly ash aggregate.

Figure 3.3 Prepared fly ash aggregates

Table 3.9 Properties of Fly Ash Coarse Aggregates

S. No	Test Particulars	Results Obtained
1.	Shape	Spherical
2.	Specific gravity	2.71
3.	Bulk density (Kg/m^3)	911
4.	Size (mm)	4.75 to 20
5.	Crushing value (%)	25.01
6.	Impact Value (%)	22.47
7	Fineness modulus	7.88

Coconut Shell Aggregate

The preparation of coconut shell aggregate is a sustainable and eco-friendly process that involves converting waste coconut shells into a valuable construction material. Coconut shells are the hard, outer layers of coconuts that are often discarded as agricultural waste. However, these shells can be repurposed to create lightweight and durable aggregate for use in construction.

Collection and Cleaning

The first step involves collecting coconut shells from coconut processing units or agricultural areas. It's essential to ensure that the collected shells are free from contaminants such as dirt, husk, and other impurities. Cleaning may involve washing and drying the shells thoroughly.

Cracking and Extraction

Once cleaned, the coconut shells need to be cracked to extract the coconut meat and water. This can be done manually or through mechanical processes. After extraction, the shells are further cleaned to remove any remaining coconut residues.

Cutting and Sizing

The coconut shells are then cut into smaller pieces to achieve the desired aggregate size. This step is crucial for obtaining uniformity in the aggregate. The sizing can be done using cutting machines or other appropriate tools.

Drying

The cut coconut shell pieces need to undergo a drying process to reduce their moisture content. Drying can be accomplished naturally through sun drying or using industrial drying methods. Low moisture content is essential to prevent issues like decay and microbial growth. Figure 3.4 illustrates the process of preparing coconut shell aggregates. The prepared dried coconut shell aggregates are tested for various mechanical and physical properties. The corresponding test results are given in Table 3.10.

Figure 3.4 Preparation of coconut shell aggregates

Table 3.10 Properties of Coconut Shell Coarse Aggregates

S. No	Test Particulars	Results Obtained
1.	Shape	Angular
2.	Specific gravity	1.24
3.	Bulk density (Kg/m3)	643
4.	Size (mm)	4.75 to 20
5.	Crushing value (%)	3.12
6.	Impact Value (%)	8.94
7	Fineness modulus	6.57

MIX PROPORTIONING

The mix design of concrete is a critical aspect in the construction industry, influencing the performance, durability, and strength of the final structure. It involves determining the proportions of various ingredients, such as cement, water, aggregates, and admixtures, to achieve the desired properties of the concrete. The selection of an appropriate mix design depends on factors like the intended use of the concrete, environmental conditions, and project specifications.

Cement, a key component, binds the other materials together, and its type and quantity significantly impact the concrete's strength and setting time. Aggregates, comprising coarse and fine particles, contribute to the concrete's structural integrity and workability. The water-to-cement ratio is a critical parameter, influencing the mixture's consistency and final strength. Controlling this ratio is vital to prevent issues like cracking and ensure long-term durability.

A well-balanced mix design not only ensures the structural integrity of the concrete but also considers factors such as durability, workability, and sustainability. The process involves thorough testing and adjustments to meet project requirements and comply with relevant industry standards. A carefully crafted mix design contributes to the overall success and longevity of the constructed infrastructure, making it a fundamental aspect of concrete technology in civil engineering.

MIX DESIGN OF CONCRETE

A control concrete with a compressive strength of 30 MPa after 28 days was developed. The mix design was conducted in accordance with IS 10262 - 1982. Appendix 1 contains the procedure for creating a mix and the resulting mix design. The proportions of materials used in the mix and the quantity of materials required for one cubic meter are listed in Table 3.11.

Mix identification and combination of light weight aggregate concrete and control concrete is shown in Table 3.12 The mix proportion obtained is 1:1.75:2.95 with constant water cement ratio 0.48. A range of 0% to 100% of the prepared lightweight aggregates, including FCA and CSA, are substituted with natural coarse aggregates. The respective replacement percentages are as follows: 0%, 20%, 40%, 60%, 80%, and 100%. There are a total of 10 trial mixes created for both FCA and CSA lightweight aggregate concrete, as well as one mix for conventional concrete. The CSA mixed concrete is categorized into five distinct categories, ranging from CSA1 to CSA5, whereas the FCA mixed concrete is categorized into five levels, ranging from FCA1 to FCA5.

Table 3.12 Mix Identification

S.NO	MIX	IDENTIFICATION
1	CC	Conventional Concrete
2	FCA1	20 % Replacement of FCA
3	FCA 2	40 % Replacement of FCA
4	FCA 3	60 % Replacement of FCA
5	FCA 4	80% Replacement of FCA
6	FCA 5	80% Replacement of FCA
7	CSA 1	20 % Replacement of CSA
8	CSA 2	40 % Replacement of CSA
9	CSA 3	60 % Replacement of CSA
10	CSA 4	80% Replacement of CSA
11	CSA 5	80% Replacement of CSA

CONCLUSIONS AND WORK SCHEDULE

Conclusion

The following conclusions were drawn from the research carried out in Phase 1:

The study's scope, objective, and significance were outlined. An investigation is conducted on the qualities of the obtained materials. The properties of prepared fly ash aggregates and coconut shell aggregates are assessed. The mix design for M3O-grade concrete is conducted, along with the proportionate blending of fly ash aggregate and coconut shell aggregate.

Work Schedule for Phase II

- Light weight aggregates such as FCA and CSA will be replaced by 0 to 100 % by natural coarse aggregates
- The characteristics of fresh concretes such as slump test, compaction factor test will be determined
- The various mechanical strength properties Compressive test, tensile test, flexural strength, Ultra sonic pulse velocity tests will be found; Also the results will be compared with conventional concrete mixes.
- Abrasion behaviour of FAA and CSA replaced concrete and conventional concrete mix.
- Various durability properties of light weight aggregate concrete are studied and those test results will be compared with conventional concrete

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