AN EXPERIMENTAL STUDY ON MECHANICAL PROPERTIES OF LIGHTWEIGHT AGGREGATE CONCRETE WHEN FINE AGGREGATE IS REPLACED WITH CINDER POWDER AND DOLOMITE POWDER

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Abstract:
Lightweight Concrete has been increasingly popular in recent years because of its many advantages over regular Concrete. Low density and high thermal conductivity are two of the main advantages of lightweight concrete. Its advantages include reduced dead weight, faster construction, and lower transportation and handling expenses. Instead of cinder from steel mills, coarse aggregate has been used. Cement has an uneven and porous surface because of mineral deposits. Due to the low specific gravity of cinder in compressive with natural particles, the cinder-based Concrete was lighter than conventional Concrete. According to the literature, the primary purpose of using cinder material is to reduce costs and the amount of garbage that must be disposed of while also aiding in reducing dead load. An experimentally study has been conducted on concrete with partial replacement of conventional fine aggregate by cinder powder. The M25 concrete mix is designed. We make concrete by replacing fine aggregate with cinder of different percentages like 0%, 20%, 40%, 60%, 80% and 100% and fine aggregate by dolomite powder in 10%, 20%, 30%, 40% and 50% with curing of 28 days.

1.0 INTRODUCTION

To minimize the weight of a structure, new construction materials have led to the development of high-strength materials. As a result of improvements in stress analysis methods, it is now possible to determine local stresses in materials with greater accuracy, resulting in weight reductions. One of the most adaptable building materials is concrete. The self-weight of a structure is critical in structural applications because it accounts for a significant amount of its dead weight. In conventional concrete, the coarser normal weight aggregate can be partially or completely replaced by low density particles to generate light weight concrete with a reasonable compressive resistance. As a result, lightweight concrete has a lower mass while keeping its structural integrity. Because of LWC's lower self-weight, it can minimize the gravitational load and seismic inertial mass, resulting in smaller members and less stress on the foundation. Aggregates make up between 60 and 70 percent of the overall volume of concrete, making them a significant component. The different material qualities such as density, specific gravity, water absorption, and so on are greatly influenced by various actions.

As Cement output is increasing at an alarming rate, it is becoming increasingly necessary to employ cement in concrete as a binder agent. The usage of concrete is expanding as a result of globalization. Concrete is the second most widely used item in the world, after water. Due to concrete's ability to be moulded in any shape, it is widely used as a structural material. Cement, fine and coarse aggregates, and water make up this combination. Getting rid of these materials is a hassle, and they pose health and safety risks and cosmetic problems.

Light weight concrete:

Lightweight concrete is a type of concrete with a low density because of the high amount of air gaps that make it possible. The term "low weight concrete" refers to concrete with a density between 1440 and 1840 kilograms per cubic meter instead of the 2240 to 2400 kilograms per cubic meter found in the typical conventional concrete mix. The use of light materials or a combination of light aggregates and standard aggregates is the only difference between this concrete and ordinary concrete.

Applications of light weight concrete:

- Considering it has so many uses like follows:
- Bridge abutment uses it.
- It can be used as packing material, meaning it may be utilized to fill cavities.
- Acoustical properties allow it to be utilized as a noise barrier.
- Heat insulation for roofs is another application for this material.
- Trench Reinstatement is another application for it.
- Water retention structures, docks and ports as well as the like are generally constructed with light weight concrete.

Objectives:

the objectives of the study are;

- To study the mechanical properties of lightweight aggregate concrete
- Experimental study with M25 concrete partial replacement of conventional fine aggregate by cinder powder.
- Experimental study on fine aggregate is replaced with cinder powder dolomite powder

2.0 LITERATURE REVIEW

Lakshmi Kumar Minapu [1] The compressive strength of lightweight concrete was lower than that of conventional concrete. From this, it can be deduced that concrete's compressive and flexural strength decreases as the percentage of ECA increases. This is because the addition of ECA reduces the density of concrete. The workability of lightweight concrete is superior to traditional concrete, and it has low heat conductivity and the ability to absorb stress. Dilip K Kulkarni [2] Worked on lightweight concrete, compared the densities of standard concrete and lightweight concrete, and published the results of their research. Density-wise, lightweight concrete is significantly less dense than standard concrete, resulting in lower dead loads, faster construction, and a more economical structure. Yasar et.al. [3] The use of basaltic pumice (scoria) and fly ash as mineral admixtures in lightweight structural concrete (SLWC) has been the subject of research that aims to reduce the dead weight of a building. Various fresh concrete parameters, such as density and slump workability, were analyzed for compressive and flexural tensile strength. T. Parhizkar et.al. [4] The results of an experimental investigation into the qualities of volcanic pumice lightweight aggregates concrete mixtures have been presented. To this goal, two types of lightweight concrete are constructed. Their physical/mechanical and durability features are researched (lightweight coarse concrete with fine natural particles and lightweight coarse and fine aggregates concrete). T. Parhizkar et.al. [5] The results of an experimental examination into the qualities of volcanic pumice lightweight aggregate concretes were reported. To this goal, two types of lightweight concrete (lightweight coarse concrete with fine natural aggregates and lightweight coarse and fine aggregates concrete) are constructed. P.C. Taylor [6] Mineral admixtures, according to a Wuhan University of Technology professor, can alter the physical and mechanical properties of High Strength Structural Light Concrete. Compaction and splitting tensile strength of

HSSLC are improved when Fly Ash is added to the mixture Concrete's 28-day compressive strength and splitting tensile strength are lower when FA is present in cementitious materials at a rate greater than 20 percent. Increases in compressive and splitting tensile strength can be achieved with the addition of silica fumes of up to 25%. Banthia, N. and Trottier,J. [7] researched concrete reinforced with deformed steel fibers and found a correlation between the inclusion of fibers and an increase in the compressive strength of lightweight fiber-reinforced concrete. Compione, G., et.al. [8] By enhancing transverse reinforcement and adding despite starting to the concrete matrix, the brittle tendency of lightweight aggregate can be overcome. They hypothesized that the inclusion of fibres may also slow material deterioration in the range of strains that exceed the peak value of strength. Campione G., Mindess S., and Zingone G. [9] Even though lightweight concrete was traditionally used only as a soundproofing or lagging material, it has lately been found to have structural benefits in the form of precast concrete structures. Arunachalam et.al. [10] As a fine aggregate, sand and quarry dust have both been explored. Researchers used cube and cylinder specimens to test lightweight concrete's compressive and tensile strength (LWC) with aluminum powder contents ranging from 1700 kg/m3 to 1800 kg/m3. As a result, the results showed that the 1:6 mix proportions yielded the highest compressive strength in both the sand and the quarry dust situations. On the other hand, Quarry dust mixes lacked the strength of sand mixtures.

3.0 MATERIALS AND METHODS

According to the IS code, a concrete mix for M25 grade has been devised. Granite and cinder concrete mixes both need a water cement ratio of 0.43. There are three layers of concrete in standard moulds, each compressed by a tamping rod and then vibrated for around 15 seconds on a vibrating table.

- Assessing the physical & mechanical properties of materials.
- Concrete mix designs are based on the qualities of the various constituents. The mix design is done in accordance with IS: 10262-2009 and IS: 456-2000 fine, and the concrete grade is taken as M25. Cinder powder is used in place of aggregate. powdered dolomite
- In order to achieve an M-25 concrete mix, the fine aggregate is replaced with cinder and dolomite powder at various percentages (such as 0, 20%, 40%, 60%, 80%, and 100%), with a cure time of 28 days.
- Test on fresh concrete using compressive test flexural test & split tensile test

Flow chart

Cement: OPC 53 grade was used in this work. It conforms to IS 12269:2013, having a specific gravity of 3.13. Initial setting time of 50 minutes has been used in present research work.

Dolomite:

Dolomite, also known as Eco sand, is produced by ACC Cements, Coimbatore. Eco sand (finely graded silica) is a byproduct of cement making that can be used to improve concrete production. Because of its micro-filling effect in concrete, moisture resistance and lifespan are improved. Crushing of dolomite powder results in the production of this byproduct. It was necessary to import cinder particles from Telangana for this investigation. Dolomite costs Rs. 2500 per kilo of the mineral in question. Dolomite powder is shown in Figure 1.

Figure 3.1. Dolomite powder

Dolomite is an anhydrous carbonate mineral made of calcium magnesium carbonate, and it is also used to characterize sedimentary carbonate rocks. Dolostone is another name for dolomite. Depicted is the rock from which dolomite powder is made.

Table 3.1: Physical Properties of materials

Test	M sand	Dolomite
Specific gravity	2.59	2.51
Fineness modulus	2.320	0.89
Water absorption	2.84%	8.49%
Grading zone	Zone II	Zone IV

Cinder powder:

This type of material is called pyroclastic. Extrusive igneous rocks, such as cinders, are made up of particles of solidified lava. A cinder's appearance can range from brown to black to crimson, depending on its chemical composition and how long it has been outside. Cinders and pumice are both made of the same material.

Figure 3.2: Cinder powder

MIX DESIGN

In an experiment, cinder powder was used to replace some of the normal fine aggregate in concrete. Concrete mix M25 has been designed. With a 28-day cure, we replace fine aggregate with cinder in various percentages (such as 0 percent; 20%; 40%; 60%; 80%; and 100%) and dolomite powder in various percentages (10 percent; 20%; 30%; 40%; and 50%).

Grade designation: M25
Type of cement: OPC 53
Min cement content: 320 kg/m³
Maxi nominal size of aggregate: 20mm
Maximum water cement ratio: 0.55
Workability: 100mm
Exposure condition: Severe
Degree of supervision: Good
Type of aggregate: Crushed
Maximum cement content: 465kg/m³

M25 Grade concrete:

The nominal cement, sand, and fine aggregate to water ratio for M25 grade concrete is 1:1:2, however the actual cement, sand, and aggregate to water ratios range from 0.4 to 0.6.

Determination Of Target Strength

Himsworth constant for 5% risk factor is 1.65. In this case standard deviation is taken from IS:456 against M 25 is 4.0.

$$f_{target} = f_{ck} + 1.65 \times S$$

$$= 25 + 1.65 \times 4.0 = 31.60\ N/mm^2$$

Selection of water cement Ratio

water-cement ratio=0.50 Based on experience, adopt water-cement ratio as 0.43, for the target mean strength and required workability 0.43<0.50, hence O.K.

Figure 3.3: Sample specimens

Sieve Analysis

The particle size distribution of finely graded silica is quite similar to that of silt (less than a 0.075mm). For the fineness test, an eco-sand sample was used in accordance with IS 2386: 1963(Part 1). Analysis results for cinder and dolomite powders are shown in this table.

Table 3.2: Sieve Analysis

% Replacement of dolomite in Fine Aggregates	Fineness modulus	Grading zone
0	2.320	II
10	2.196	II
20	2.179	II
30	1.889	III
40	1.831	III
50	1.609	III
60	1.505	III
70	1.287	IV
80	1.131	IV
90	0.99	IV
100	0.92	IV

Compressive Strength:

Compressive Strength Concrete cube compressive strength can be measured using this test. After casting and curing for 7-14 and 28 days in tap water, 150X150X150mm sized specimens were ready to use. A cube compression test is performed under a digital compressive testing equipment after the specimens have been dried in the open air. Computed using the fundamental formula F = P/A, the cube compressive strength A is the cross-sectional area (in N/mm2) divided by the failure load, and f Load at failure (N) is P = Area of the specimen P (mm2)

Figure 3.4 : Compression Testing Machine

Split tensile strength:

Due to its fragile nature, concrete is extremely prone to deformation in tension. Hence. It's not expected to be able to withstand the direct pressure." When tensile forces exceed the tensile strength of concrete, cracks form. As a result, the tensile strength of concrete must be measured in order to establish the maximum load at which concrete members are susceptible to failure.

Figure 3.5: Split tensile strength Machine

Figure 3.6: Specimen under Flexural Strength Test

Curing of Specimen:

- Casted specimen should be stored in a place at a temperature of 27° +/- 2°C for 24 +/- 0.5 hrs from the time addition of water to the dry ingredients.
- After that, the specimen should be marked and removed from the mould and immediately submerged in clean fresh water

or saturated lime solution and kept there until taken out just prior to the test.

- The water or solution in which the specimens are kept should be renewed every seven days and should be maintained at a temperature of 27° +/- 2°c.
- For design purpose, the specimen cured for 56 days.
- At last, for each reading, three specimens shall be casted and tested. Then, the average tensile strength will be taken.

Flexural strength:

Flexural strength, also known as mechanical properties, bend strength, or transverse rupture strength, is a material parameter defined as the stress in a material right before it yields in a flexure test. There are two types of transverse bending tests: circular and rectangular cross-sectional specimens are bent until they break or yield using a three-point flexural test technique, respectively.

4.0 RESULTS AND DISCUSSIONS

To determine how much stress concrete members can bear, the Flexural Tensile Strength must be calculated. When the material is being lowered, it is referred to as the modulus of rupture. Pavement slabs, runways, and detecting deflection or fracture breadth are all examples where modulus of rupture is useful. Flexural tension is critical here. The samples were chopped into sections of 150mm × 150mm x300mm in diameter to evaluate their strength. It was established utilizing point loading that the flexural strength achieved. These samples were tested with a 1000kN UTM capacity. Using a light-weight aggregate in place of traditional coarse aggregate in a concrete experiment has been done. Based on the ISI approach, the M25 concrete mix is created. Concrete is made by substituting fine material with cinder of various percentages, such as 0%, 20%, 40%, 60%, 80%, and 100%, with curing periods of 7 and 28 days.

COMPRESSIVE STRENGTH

Table 4.1: Strengths of light weight cinder concrete M25 of different mixes.

S. No	Percentage Replacement Of C.A (%)		Compressive Strength (MPa)
	Natural Aggregate %	Cinder Aggregate %	
Mix 1	100.0	0	36.40
Mix 2	80.0	20.0	33.60
Mix 3	60.0	40.0	32.05
Mix 4	40.0	60.0	31.40
Mix 5	20.0	80.0	29.90
Mix 6	0	100.0	27.85

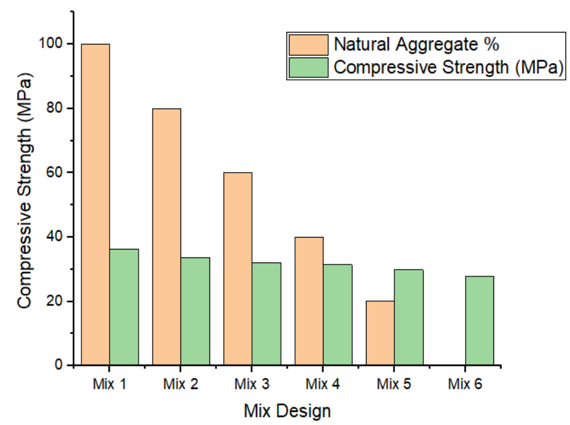

Figure 4.1: Compressive Strength (MPa) vs Natural Aggregate %

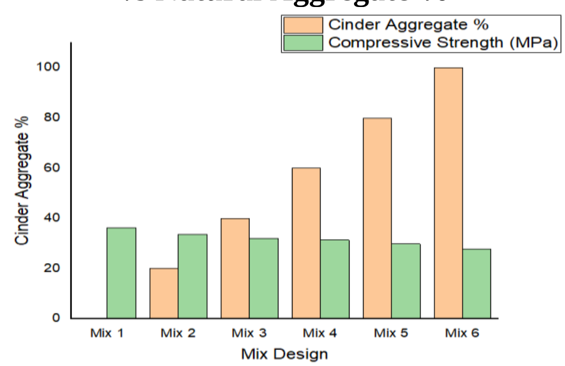

Figure 4.2: Compressive Strength (MPa) vs Cinder Aggregate %

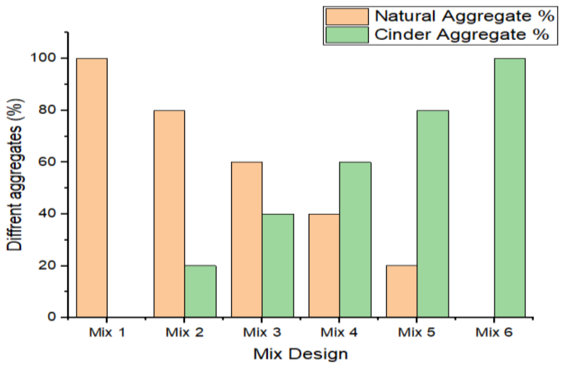

Figure 4.3: Variation of M25 Compressive Strength with variation of Cinder Aggregate

A compressive strength of concrete of 32.05 MPa is achieved with a 40% replacement level of cinder aggregate, exceeding the intended mean strength of 31.6 MPa for the M25 design mix.

Table.4.2. Strengths of light weight cinder concrete M25 of different mixes.

S. No	Percentage Replacement Of F.A (%)		Compressive Strength (MPa)
	River Sand %	Cinder Powder%	
Mix 1	100.0	0	32.70
Mix 2	90.0	10.0	32.10
Mix 3	80.0	20.0	31.74
Mix 4	70.0	30.0	31.37
Mix 5	60.0	40.0	30.96
Mix 6	50.0	50.0	30.73

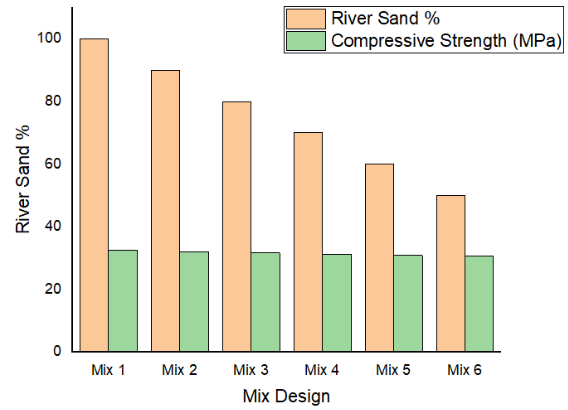

Figure 4.4: Compressive Strength (MPa) vs River Sand %

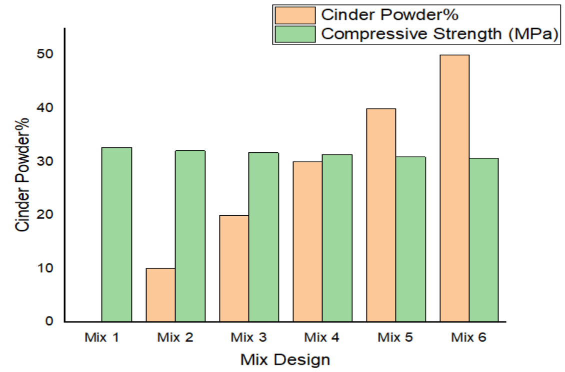

Figure 4.5 : Compressive Strength (MPa) vs Cinder Powder%

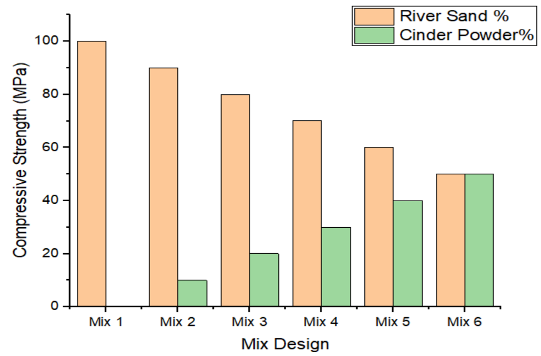

Figure 4.6: Variation of M25 Compressive Strength with variation of copper powder

The optimal temperature of cinder aggregate is 40 percent, because it achieves the maximum compressive strength. The results demonstrate that as the percentage of cinder powder is increased, the strength value gradually decreases.

Split tensile strength

Table 4.3: Tensile strength of cinder concrete M25 of different mixes.

S. No	Percentage Replacement Of C.A (%)		Tensile Strength (MPa)
	Natural Aggregate %	Cinder Aggregate %	
Mix 1	100	0	3.93
Mix 2	80	20	3.65
Mix 3	60	40	3.54
Mix 4	40	60	3.37
Mix 5	20	80	3.06
Mix 6	0	100	2.82

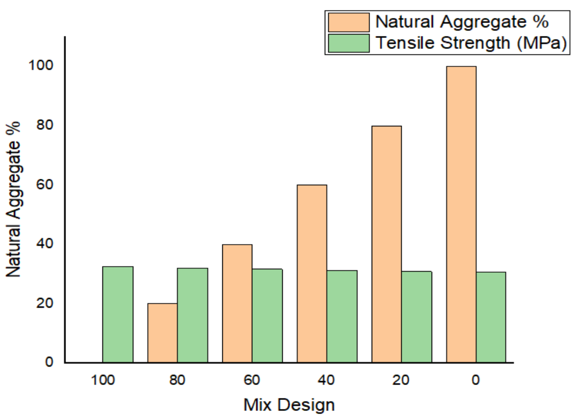

Figure 4.7: Tensile Strength (MPa) vs natural Aggregate%

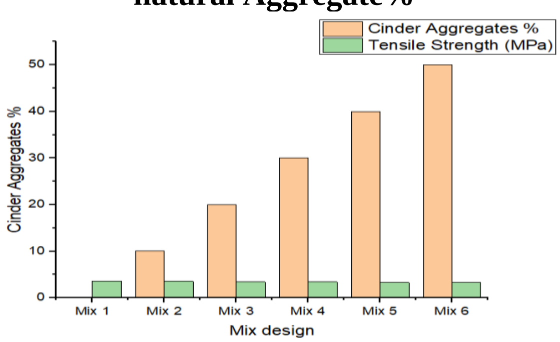

Figure 4.8: Tensile Strength (MPa) vs Cinder Aggregate%

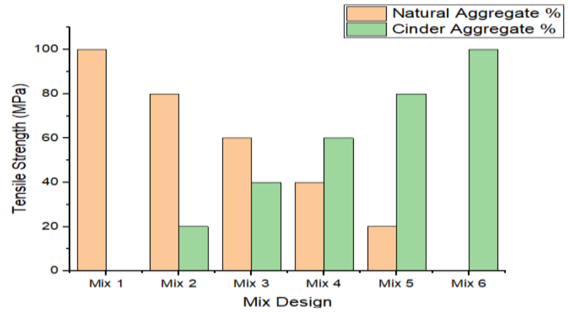

Figure 4.9: Variation of M25 Split Tensile Strength

The results conclude that the tensile strength in split decrease gradually with increasing replacement levels of cinder aggregate.

Table.4.4. Tensile Strength of cinder concrete M25 of different mixes.

S. No	Percentage Replacement Of F.A (%)		Tensile Strength (MPa)
	River Sand %	Cinder powder %	
Mix 1	100	0	3.63
Mix 2	90	10	3.54
Mix 3	80	20	3.46
Mix 4	70	30	3.41
Mix 5	60	40	3.32
Mix 6	50	50	3.29

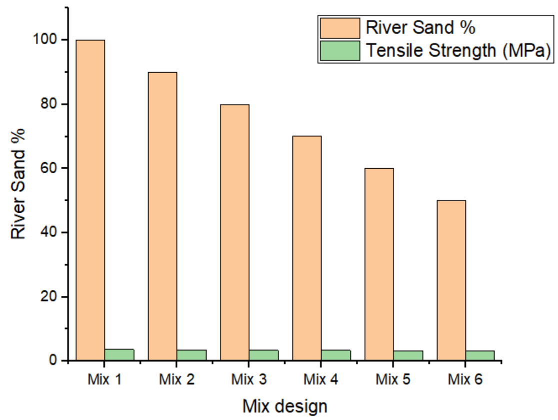

Figure 4.10: Tensile Strength (MPa) vs River sand %

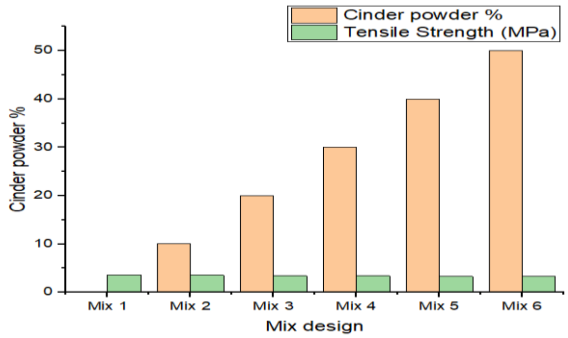

Figure 4.11: Tensile Strength (MPa) vs Cinder powder %

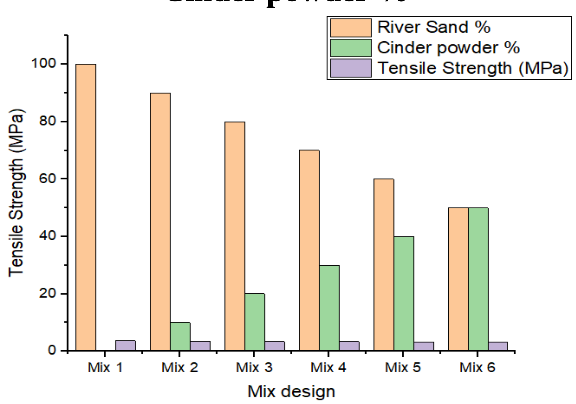

Figure 4.12. Variation of M25 Split Tensile Strength with variation of cinder.

In order to provide the best possible strength, 40 percent cinder aggregate is considered ideal. The results demonstrate that as the proportion of cinder powder is increased, the ultimate strength progressively decreases.

FLEXURAL STRENGTH

Table 4.5: Strengths of cinder concrete M25 of different mixes.

Mix design	Percentage Replacement of Natural Aggregate (%)		Flexural Strength (MPa)
	Natural Aggregate %	Cinder Aggregate %	
Mix 1	100	0	7.75
Mix 2	80	20	7.12
Mix 3	60	40	6.04
Mix 4	40	60	5.67
Mix 5	20	80	5.64
Mix 5	0	100	5.17

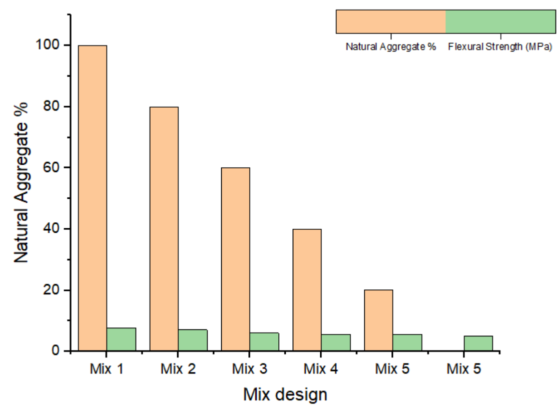

Figure 4.13: Flexural Strength (MPa) vs Natural Aggregate %

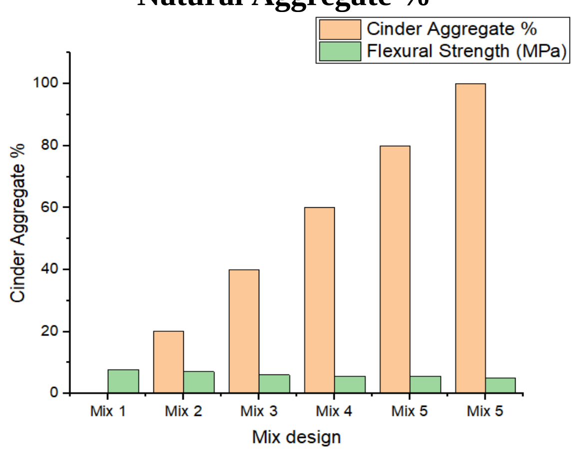

Figure 4.14: Flexural Strength (MPa) vs Cinder Aggregate %

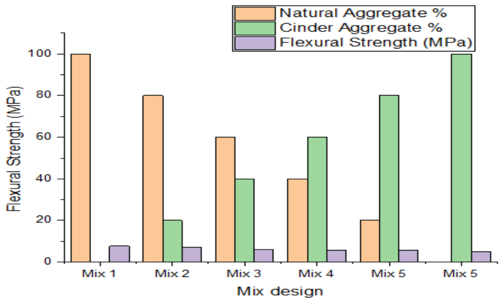

Figure. 4.15. Variation of M25 Flexural Strength with variation of cinder aggregate

The results conclude that the flexural strength decrease gradually with increasing replacement levels of cinder aggregate**.**

Table.4.6. Strengths of cinder concrete M25 of different mixes.

S. No	Percentage Of Replacement Fine aggregates (%)		Flexural Strength (MPa)
	River Sand %	Cinder powder %	
Mix 1	100	0	6.48
Mix 2	90	10	6.14
Mix 3	80	20	6.09
Mix 4	70	30	5.59
Mix 5	60	40	5.37
Mix 6	50	50	5.09

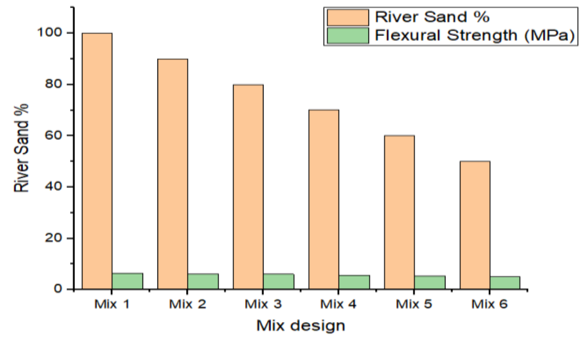

Figure 4.16: Flexural Strength (MPa) vs River sand %

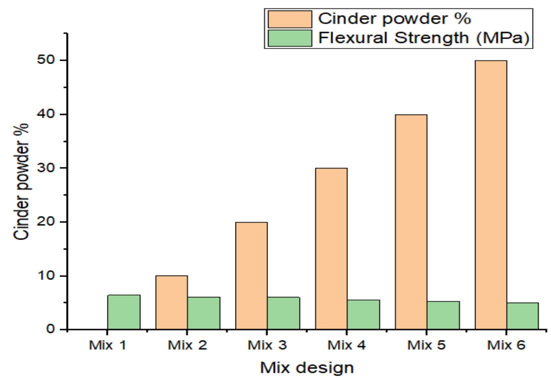

Figure 4.17: Flexural Strength (MPa) vs Cinder powder %

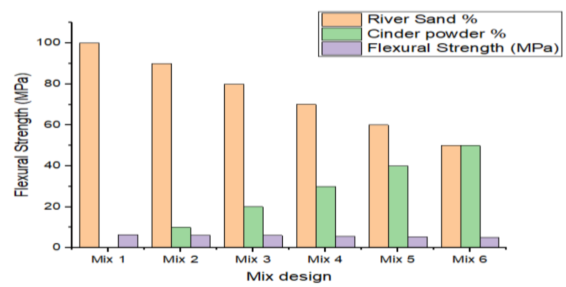

Figure 4.18 Variation of M25 Flexural Strength with variation of cinder

Results indicate a progressive decline in strength as the percentage of cinder powder increases.

CONCLUSION

Light-weight cement is expected to become more popular in the next years because of its cost-effectiveness. As a result, lightweight aggregate is an excellent alternative to the heavy weight aggregate currently being employed in Indian construction markets. An enormous demand exists in India for LWCs and new obligatory standards should be implemented to increase utilization. Using them serves many purposes.

Based on the experimental investigations the following conclusions are drawn.

- Replacement of cement by dolomite powder and fine aggregate by cinder powder has shown improvement in the strength parameters of concrete
- It is observed that the maximum compressive strength, split tensile strength and flexural strength of concrete is increased mix design IV respectively, as compared with that of conventional concrete when 40% (optimum percentage) of cement is replaced by Dolomite Powder.
- Using Dolomite powder and cinder powder at the optimum percentage (Dolomite powder and cinder powder) resulted in lower construction costs, according to a study. The ecosystem is also safeguarded from waste disposal materials when natural resources are used.

Using cinder powder in place of some of the fine aggregate reduces the final product's strength by a relatively minor proportion. In comparison to conventional concrete, cinder aggregate concrete that was 40 percent reconstituted with cinder achieved the same ultimate strength goal as the latter. Cinder aggregate has been shown to be a 100 percent fine aggregate alternative in tests. This machine has the capability of producing physically light concrete.

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