"COMPARATIVE STUDY ON STRENGTH PROPERTIES OF LIGHT WEIGHT AGGREGATE CONCRETE WITH PARTIAL REPLACEMENT OF COARSE AGGREGATES WITH CRUSHED CINDER AND BRICK BATS"

PRATHIBHA A R[1], Dr. ANILA KUMAR. C.P [2]

[1]Post Graduate Student in Structural Engineering, BIET College, Davangere,
[2]Professor and HOD, Civil Engineering, BIET, Davangere. 577004 Karnataka, India

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Abstract - *Concrete, because of its density increases the dead load on the structure. There are some places in the structure wherein the normal concrete is not beneficial. In some structures, the walls must have proper thermal insulation. In this regard, concept of light weight concrete has originated. The current study is made to check the possibility of reducing the strength and density of the normal concrete by replacing coarse aggregate by Cinder and Brick Bats.*

Key Words: Light Weight aggregate Concrete, Crushed Cinder, Brick Bats, Super Plasticizers (Conplast-430) and Compressive strength.

1. INTRODUCTION

Concrete is one of the construction materials popularly used and durable. Concrete is a composite material comprising, a mixture of cement, fine aggregate, coarse aggregate, water, and chemical compounds (if needed). In practical terms, aggregates are the most significant constituents. In concrete approximately 75- 80% of the volume is dominated by aggregates, the concrete is given sufficient strength and rigidity by aggregates. Cement can be used as binding agent & it reacts with water chemically to develop a solid matrix which holds all the components together. Because of its mould ability, high compressive strength, Structural stability and economic consideration concrete is highly used construction material. Normal concrete density varies from 2,200 to 2,600 kg/m^3.

1.1. Light Weight Concrete

Concrete, due to its high self weight increases the dead load on the structure. A number of research projects has been carried out in order to reduce the self-weight of the building materials on the structure leading to the development of lightweight concrete. The concrete whose density (300 to 1,850 kg /m^3) is relatively lower than that of conventional concrete (2,200 to 2,600 kg / m^3) is referred to as light weight concrete. It is an essential and robust material for modern construction. It has properties similar to the conventional weight of concrete, but is usually 25 to 35% lighter. Structural light weight reinforced concrete addresses the problems of weight and strength of buildings and structures exposed to them. This preserves large voids, and when mounted on a wall, it does not form layers of laitance or cement film. A proper water cement ratio is, however, crucial to certifying that there is adequate consistency between cement and water. Even these concrete were widely used for structural purposes, where its use could result in lower overall construction costs than standard weight concrete. This also offers increased thermal insulation. The use of low-density concrete can give major advantages in terms of small section lateral loads and a resulting reduction in the size of the foundation.

1.2. Classification of Light Weight Concrete

The different types of lightweight concrete according to method of production:

a) Lightweight Aggregate Concrete

Using the apparently low specific gravity porous lightweight aggregate, i.e., less than 2.6. That kind of concrete is called Lightweight concrete aggregate. Light weight aggregate is a category of coarse aggregate used in the manufacture of lightweight concrete products include concrete block, structural concrete, and pavement. The development and production of new forms of artificial LWA (Lightweight aggregate) eventually thereafter made it possible to implement high strength LWC, ideal for structural work. Listed below are classifications of lightweight aggregates suitable for structural reinforced concrete:-

I. Natural Light Weight Aggregates

- **Pumice** are volcanic rocks which exist in many regions of the world. A lightness is caused by the escape of gas from the molten lava as it erupts from deep beneath the crust of the earth.
- **Diatomite** is a moist amorphous silica, formed from the remains of marine microscopic plants called diatoms. Often named as Kieselghur.
- **Scoria** is indeed a volcanic lightweight aggregate which is typically dark in colour and comprises larger and irregularly shaped cells unassociated to each other. So it's substantially weaker than pumice.

II. Artificial Light Weight Aggregate

- **Cinder** is the element which falls there under light weight aggregate group. It is indeed a by-product of companies manufacturing steel & iron.

- **Foamed Slag** is produced by quick-quenching blast furnace slag, a by-product produced in the manufacture of blast furnace slag cement.

- **Brick bats** are also one of the types of aggregates-used in many regions where natural aggregates are not easily accessible or expensive.

b) Aerated Concrete

By adding large voids inside the concrete or mortar mass; these voids have been clearly distinguished from the extremely fine voids created by air entrainment. These form of concrete were technically known as Aerated, Cellular, foamed or Gas concrete.

c) No Fines Concrete

By omitting the fine aggregate from its mix so there would be a sufficient number of interstitial voids; typically, normal weight coarse aggregate has been used. This concrete operates as No-Fines concrete.

2. LITERATURE REVIEW:

- **P.S. Raghuprasad, et.al (2000)** in their paper "Experimental investigations on solid concrete blocks with partial replacement of coarse aggregate with cinder aggregate" analysed the field aggregates and partly replaced by cinders for standardized solid concrete blocks (12 mm) and tested for 3 days, 7 days and 21 days of age compressive strength. The results concluded that solid concrete block with a 15% coarse aggregate substitution was more reliable than conventional concrete by filtering reports.

- **Rashid, et.al (2008)** in their paper "Higher Strength Concrete Using Crushed Brick as Coarse Aggregate" found that the brick aggregate was achievable with greater strength (f_{cu} = 31 – 45.5 N /mm^2). Crushed bricks are used as a coarse concrete aggregate, whose strength is substantially greater than that of the bricks under consideration. This concrete's unit weight was roughly 13 percent lower than standard concrete. Compared to traditional concrete, a radical decrease in the compressive strength of crushed brick aggregate was observed due to the improved water-cement ratio.

- **Cachim (2009)** in his paper "Mechanical Properties of brick aggregate concrete. Construction and Building Materials" estimated that 15% of the brick aggregate could replace the natural aggregate without impacting its strength. Measured findings suggested that somehow brick residues could also be used as a substitute for natural coarse aggregates in concrete without increasing concrete properties to replace 15 percent and with a reduction of upto 20 percent to replace 30 percent. Its method of production as well as the form of its bricks tends to affect the properties of the finished concrete.

- **Bhaskar Desai, et.al (2014)** in their paper "Some studies on strength properties of Light weight cinder aggregate concrete" examined the strength of lightweight concrete with the use of crushed cinder in various and specified characteristics, such as compressive strength, split tensile strength , elastic structure, density & shear stress. The cement mix M20 is built with the ISI method (coding specifications). They replaced coarse aggregates with cinders of various amounts, including 0%, 25%, 50%, 75 %, and 100% by curing for 7 and 28 days. With the increase in percentage of cinder, the cube compressive strength continuously decreased. Nevertheless, although the conventional aggregate is 75% substituted by the cinder aggregate, it's more than the conventional aggregate 's target mean strength.

3. MATERIALS USED AND THEIR PROPERTIES

The objective of present study was to utilize waste brick bats and cinder as light weight aggregate material and compare the strength properties

3.1. Cement:

In the present study, OPC 43 (Coramandel) is used and tested for basic properties. The table below summarizes the outcomes of various cement studies.

Table 3.1: Test Results for Cement

SL. NO	PROPERTY	VALUE	STANDARD VALUES (IS 12269– 2013)
1	Standard Consistency (%)	31	Not specified
2(a)	Initial setting time (min)	36	30 (minutes)
2(b)	Final setting time (min)	628	600 (minutes)
3	Specific Gravity	3	Not specified

3.2. Fine Aggregates:

The fine aggregates are obtained locally for the experimental investigation conforms to IS 383-1970 requirements. The specific gravity of such natural sand has been determined to be 2.84.

3.3. Coarse Aggregates:

Apart from water and cement, the coarse aggregate is one of the essential qualities in concrete production. This comprises approximately 60-75% of overall concrete supply. Locally available coarse aggregates with a maximum size of 20 mm have been used in the work. The aggregates were washed to remove dust and dirt and dried to a dry surface. The aggregates have been verified to Indian Standard Specifications IS 383-1970. It was found that the specific gravity of coarse aggregates was 2.65.

3.4. Brick Bats:

Bricks are a flexible & versatile and it is a structural material with outstanding load-bearing properties. It is the most commonly used material in constructing masonry walls. Waste bricks were taken and broken to pieces corresponding to that of coarse aggregates. Specific gravity was determined and found to be 2.22.

3.5. Cinder:

Waste cinder materials available locally were used.

3.6. Super-Plasticizer:

Conplast SP430 was used as Super plasticizer. Its specific gravity ranges from 1.10 to 1.20.

3.7. Water:

The Potable water is usually used for experiments that are free from acidic concentrations and organic substances. Water is a fundamental ingredient that makes up a paste when associated with cement which binds the aggregate together. It also allows the concrete to harden, by a mechanism called hydration. Hydration is a chemical phenomenon in which the significant cement compounds form chemical bonds with molecules of water and become hydrated.

4. EXPERIMENTAL PROCEDURE

Concrete mix design was carried out as per IS 10262-2019. Considering coarse aggregates, the proportion obtained was 1 : 2.84 : 4.16 with 0.48 water cement ratio. In this proportion the replacement of coarse aggregate by brick bats and cinder is made with different percentages 0 , 25, 50, 75 and 100 with 28 days of curing.

5. RESULTS AND DISCUSSIONS

A control concrete mix with proportion of 1: 1.45: 2.76 with water cement ratio 0.48 is designed. Coarse aggregates were replaced by cinder or brick bats at the rate of 0, 25, 50, 75 & 100 by weight of coarse aggregates and machine mixing was adopted. Initially, cement and sand were mixed thoroughly to which coarse aggregates and cinder or brick bats were added. To this dry mix, water along with the super plasticizer were added. Mixing was done until a good homogeneous mixture is obtained.

5.1. Test Results of Fresh Concrete:

- **Slump Test:**

The test is mainly performed to measure the concrete's workability which is prepared in the laboratory or field. This helps to check the consistent quality of the concrete during construction. This also means the ratio of the mixture to the water cement. Here a concrete mixture of grade M20 by weight is prepared with an correct water cement ratio by means of a tool with a slump cone in the shape of a frustum cone with a height of 30 cm, a base diameter of 20 cm and a top diameter of 110 cm, a base plate, a tamping rod and a measuring scale. Slump test is performed to determine the workability. For determining the strength characterstics, concrete cubes of dimension 150 mm*150 mm*150 mm were casted and after 24 hours, they were kept for curing. The cubes were tested for their strengths after 28 days.

The following table shows the slump values of fresh concrete with 0%, 25%, 50%, 75% &100% replacement of coarse aggregates by crushed cinder and brick bats (replacement by mass).

a) Replacement of Cinder:

Table 6.1: Test Results of Slump with Cinder Replacement

% Cinder	Slump (mm)
0	75
25	89
50	79
75	100
100	117

b) Replacement with Brick bats:

Table 6.2: Test Results of Slump with Brick Replacement

% Brick bats	Slump (mm)
0	75
25	87

50	105
75	119
100	125

5.2. Test Results of Hardened Concrete:

The compressive strength of concrete obtained by replacing coarse aggregates with cinder and brick bats in different % are tabulated below

- **Comparison of Weight**

The cubes were weighed after removing from the mould before keeping for curing. After 28 days of curing, the cubes were once again weighed.

Table 6.3: Comparison of Weight of Cinder Concrete before Curing and after Curing.

% Cinder Replacement	Average Weight before Curing	Average Weight after Curing	Average
0	8.34	8.36	8.35
25	8.27	8.31	8.29
50	8.2	8.34	8.27
75	7.96	8.06	8.01
100	7.64	7.82	7.73

Table 6.4: Comparison of Weight of Brick Bats Concrete before Curing and after Curing

% Brick Bats Replacement	Average Weight before Curing	Average Weight after Curing	Average
0	8.34	8.36	8.35
25	8.06	8.16	8.11
50	7.82	7.98	7.9
75	7.44	7.6	7.52
100	6.9	6.98	6.94

- **Compressive Strength**

The capacity of the material to carry load on its surface without cracking and deflection is known as compressive strength. In other words, it is also defined as the load ratio applied to the cross-section area of the specimen. The samples prepared are tested after 28 days of treatment in the CTM where the load is applied until the specimen fails. As the age of concrete increases, the strength also increases.

5.2.1. Test Results for Compressive strength with 28 days of Curing for M20 Grade by Cinder Replacement:

Table 6.5: Results of Compressive Strength for M20 Grade with Crushed Cinder Replacement cured for 28 days

Sl. NO	Replacement of cinder (%)	Compressivet strength (N/mm2)	Avg Compressive strength (N/mm2)	% Decrease in strength
1	0	30.67	31.55	-
		31.55		
		32.44		
2	25	29.33	28.44	9.86
		27.55		
		28.44		
3	50	23.11	22.52	28.63
		22.67		
		21.77		
4	75	18.22	17.93	43.2
		17.33		
		18.22		
5	100	16	16.74	46.94
		16.89		
		17.33		

5.2.2. Test Results for Compressive strength with 28 days of Curing for M20 Grade by Brick Bats Replacement:

Table 6.6 : Results of Compressive Strength for M20 Grade with Crushed Brick Bats cured for 28 days

Sl. no.	Replacement of Brick bats (%)	Compressive strength (N/mm^2)	Avg Compressive strength (N/mm^2)	% increase in strength
1	0	30.67	31.55	-
		31.56		
		32.44		
2	25	24.89	24.7	21.62
		25.33		

		24		
3	50	20.88	19.7	38.02
		19.55		
		18.22		
4	75	8.44	8.76	70.42
		10.22		
		9.33		
5	100	8.44	7.96	75.58
		5.33		
		9.33		

5.3. Discussion on Test Results

5.3.1. Workability of Fresh Concrete: The following graphs represent the variation of workability of concrete:

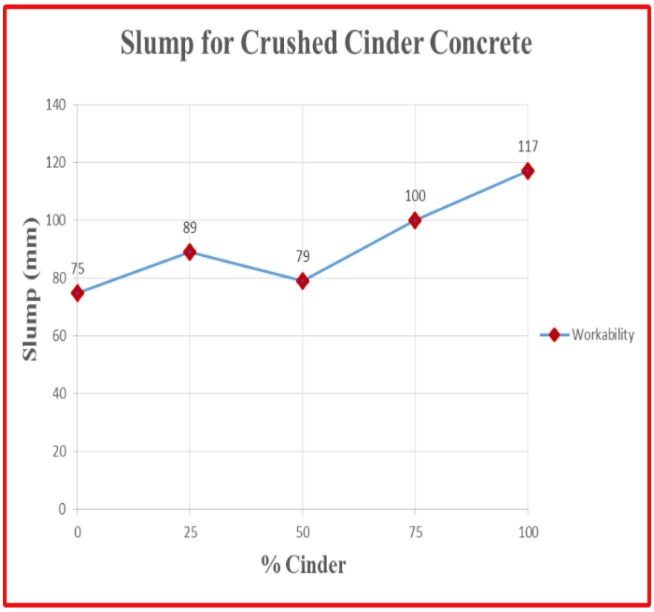

Fig 6.1: Slump Values for Various % of Cinder in Concrete

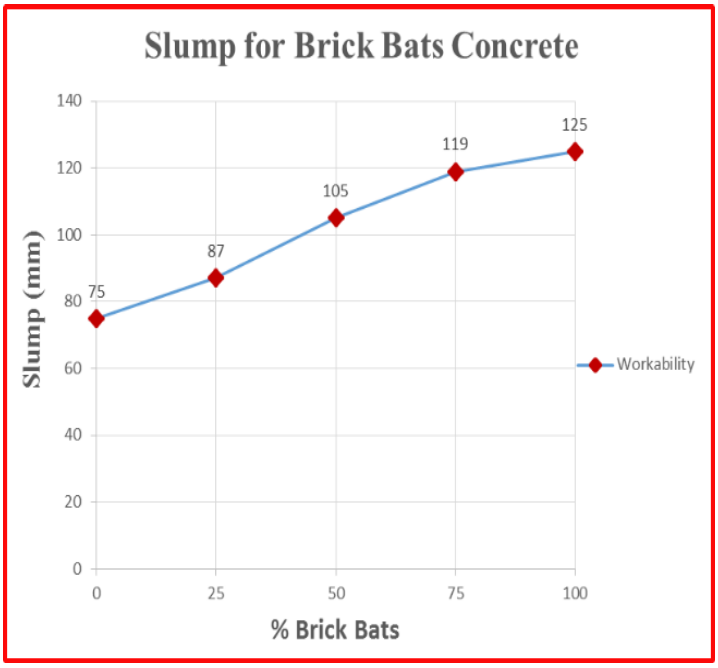

Fig 6.2: Slump Values for Various % of Brick Bats in Concrete

5.3.2. Compressive Strength

The following graphs show variations of compressive strength of concrete.

- Concrete produced by replacing coarse aggregates with crushed cinder in different percentages.

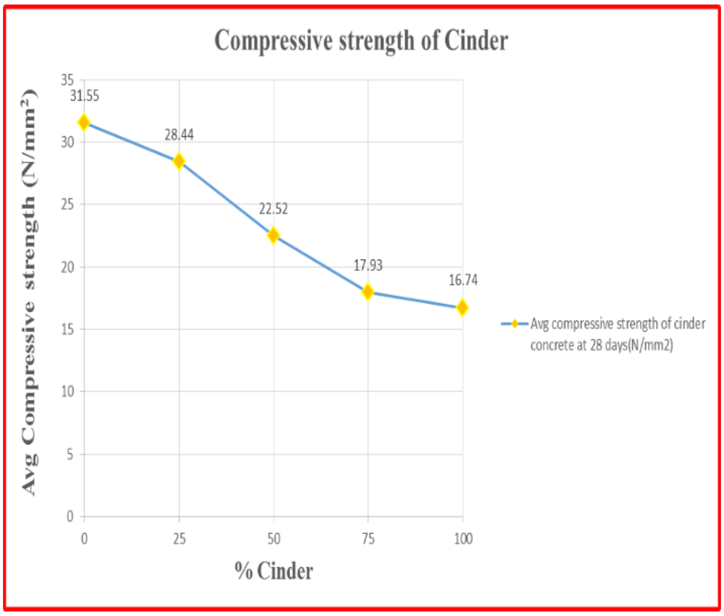

Fig 6.3: Compressive Strength of Concrete using Crushed Cinder

- Concrete produced by replacing coarse aggregates with crushed brick bats in different percentages.

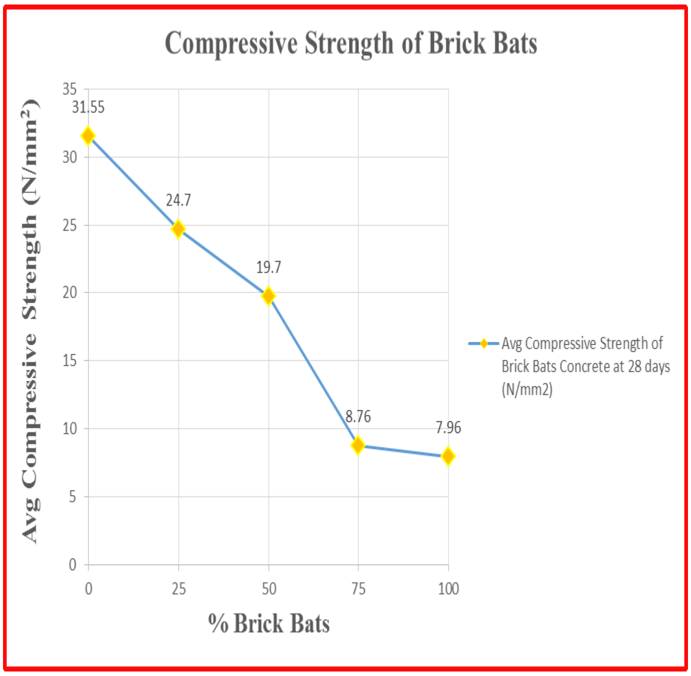

Fig 6.4: Compressive Strength of Concrete using Brick Bats

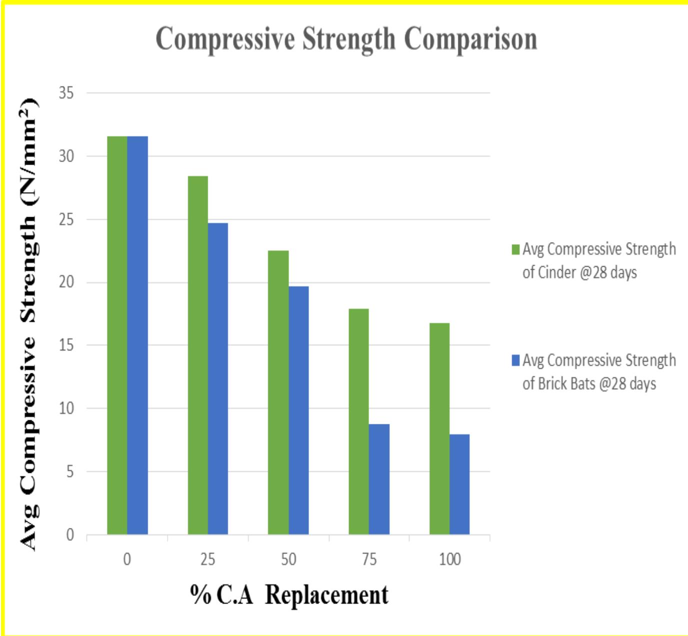

Fig 6.6: Compressive Strength Comparison of Cinder and Brick Bats

- **Comparison on Properties of Fresh concrete & Hardened concrete:**

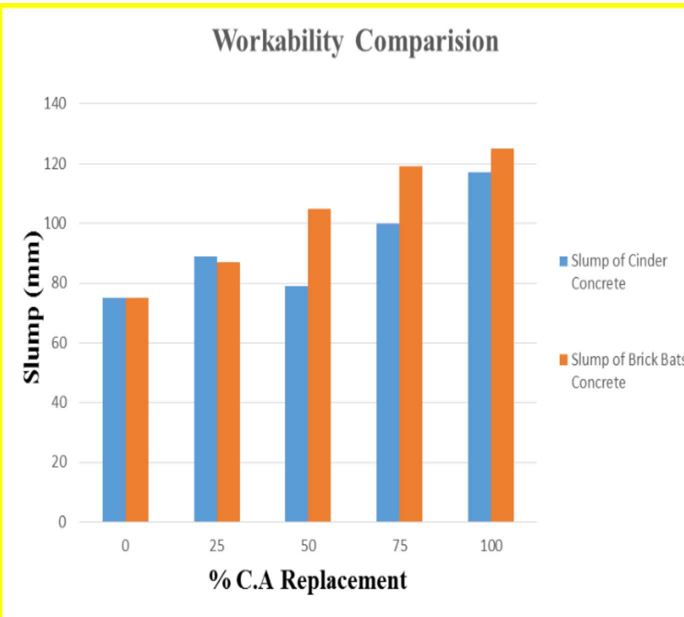

Fig 6.5: Comparison of Workability of Cinder and Brick Bats

- The test results for fresh concrete & for hardened concrete indicates the following observations
- Slump value for fresh concrete is comparatively less to that of concrete with cinder and with brick bats. Thus, it can be concluded that a better workable concrete can be obtained with both the replacing material.
- The workability property of concrete with cinder is less than that of concrete with brick bats. This may be due to more intra particle binding in cinder material compared to brick bats.
- The strength property of the two concretes indicates that there is a reduction in the compressive strength. Whenever coarse aggregates are completely replaced by cinder, the compressive strength obtained is 16.74 MPa with % decrease as 46.94.
- Since coarse aggregates were replaced completely by brick bats, the compressive strength was 7.96 MPa with % decrease of 75.58 whereas at 50% replacement, the compressive strength with cinder is 22.52 and with brick bats is 19.7.

6. CONCLUSIONS

- With the observations of the weight, it can be concluded that concrete with cinder gives lighter weight as compared with brick bats.
- With this, we can also be conclude that replacement of coarse aggregates by cinder will not only reduce

the weight, but also there will be maintenance of strength both at 50% and 100% replacement whereas in case of brick replacement, even though light weight aggregate concrete is obtained, strength achieved at 50% is good compared to 100% replacement.

- Thus it can be concluded that in place where strength is also a required factor for light weight aggregate concrete. Cinder can be used as a partial replacement or complete replacement in such places where concrete is used only for the insulation purpose and brick bats can be used as a replacing material.

- With the above testing results, it is inferred that when compared with normal concrete, the crushing (quality) strength is minimum.

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BIOGRAPHIES

PRATHIBHA A R
Post Graduate student, Dept. of Civil engineering BIET College, Davangere

Dr. ANILA KUMAR. C.P
Professor and Head Department of Civil engineering BIET, Davangere