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Strengths Analysis of Concrete by using Cinder Aggregate

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ABSTRACT: Light weight concrete has become more popular in recent years owing to the tremendous advantages it offers over the conventional concrete. The main specialties of lightweight concrete are its low density and thermal conductivity. Its advantages are that there is a reduction of dead load, faster building rates in construction and lower haulage and handling costs. We are replacing the cinder instead of coarse aggregate; it is obtained from steel industries. The surface of the cinder is usually rough and high porous due to mineral structures. Low specific gravity of cinder in compression with natural aggregates resulted in the concrete made with cinder to be lighter than normal concrete. Based on the literature, the main function for usage cinder material is to minimize the cost and it is reduced to disposal of waste material and it helps in reduction of dead load. An experimentally study has been conducted on concrete with partial replacement of conventional coarse aggregate by another light weight aggregate. The M20 concrete mix is designed using ISI method. We make concrete by replacing coarse aggregate with cinder of different percentages like 0%, 25%, 50%, 75%, and 100% with curing of 7 and 28 days. Among all the percentages the better compressive strength obtained percentage is selected.

KEYWORDS: Light weight concrete, thermal conductivity, M20 concrete mix, ISI method.

I. INTRODUCTION

In recent days, due to the developments and innovations in the new construction materials, stress analysis approaches towards finding of the weight less structures to reduce the weight of the construction has lead to development of the Light Weight Aggregate Concretes (LWAC) to increase the strengths and weights. Concrete is one of the most multipurpose material used in building construction. In structural applications, the self-weight of the structure is quite important as it represents a major portion of its dead load. Replacing partially or entirely the coarser normal weight aggregate in conventional concrete can be replaced partially or fully with low density aggregates will produces lightweight concrete that can reach a reasonably good compressive resistance [1].

The advantages of lightweight Aggregate concrete (LWAC) are its reduced mass and improved thermal and sound insulation properties, while maintaining adequate strength. The reduced self-weight of LWAC will reduce the gravity load as well as seismic inertial mass which leads to decreased member sizes as well as forces on foundation can be reduced. Aggregates contribute an important role in concrete volume as they contribute to 60 to 70 percent of the total volume. Thus they have an major influence on the different material properties like density, specific gravity, water absorption etc., Cinder is the material comes under the category light weight aggregate and it is a byproduct of steel, iron manufacturing companies. The surface of cinder aggregate is usually rough and highly porous due to mineral structure. The cinder material visually classified as having 100% crushed face and have been used for making building blocks for partition walls.

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II. RELATED WORK

To get an overview of problem building for the present research, all the available earlier studies were browsed both in India as well as around the world. Special attention was given on how the earlier workers have used LWAC towards understanding the strengths of the concrete of their study area. A brief review of available studies related to the present strength properties of concrete materials is as follows.

2.1 Seabrooks, 1988 [2]. Demonstrates the results of the 162 trial mixtures of the second phase of a three-phase programme, using aggregates from the three sources such as, two chemical admixture systems, three levels of fly ash replacement, and three levels of silica fume replacement. It is resulted that 91 day compressive strengths of the order of 65 MPa are attainable light weight concrete, although this is the threshold level of the aggregates. Further, it is concluded that a nominal increase in strength occurs with Type F ash replacement and addition of the silica fume.

2.2 Bhaskar Desai et al., 1993, 1999, 2000 [3, 4, 5]. An effort is made to study the strength properties of LWAC in various % proportions of 0, 25, 50, 75 and 100 of cinder and calculated the properties such as compressive strength, split tensile strength, modulus of elasticity, density and shear stress. And this study concludes that, mode – II failure is procured at Double Central Notched specimen geometry. Furthermore, they made finite element analysis to disembark at stress intensity factor and these geometry and finite elemental studies have applied in the investigations of mortar, cement paste, and plain concrete.

2.3 Siva lingaRao, et.al., 2011 [6]. Accomplished that, the best mean strength results of M20 concrete have occurred at the 60 percent replacement of conventional aggregate with cinder by volume along with cement replaced by 10 percent of silica fume by weight. In addition to this it is also noted that there is a slight increase in the strength of based on the during period extension and the unit weight of the cinder concrete is varying from 1980 to 2000 Kg/m³. furthermore, it is also noted that there is a decrease in density after extended curing periods.

III. MATERIALS AND METHODS

For the study of various strength properties such as compressive and tensile strengths for cube and cylindrical setups, Young's modulus and Density, totally 25 specimens have been cast and tested. The ordinary Portland cement of 53 grade conforming to IS: 8112 [7] was used such that it is to react slowly with the calcium hydroxide that is liberated during cement hydration. The river sand used in this experimental investigation was local river sand confirming to Grading Zone II of IS: 383-1970 [8]. The river sand was screened, to eliminate waste material and over size particles. The Cinder which is passing through 30 mm and retained on 20 mm I.S sieve were used as replacing coarse aggregate and they met the grading requirements as shown in Plate 1. Cinder characterised by its rough and highly porous surface, 100 % crushed face, and low specific gravity. The cinder was crushed and soaked in water for 2 hours for water treatment then kept for drying.



Fig. 1 Cinder wastage of steel industries

Here a constant water cement ratio of 0.50 has been adopted. The experimental part of the investigation has been planned in the following two stages.

Stage 1: Casting of specimens.

Stage 2: Testing of specimens.

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i. Casting of Specimens: The mix design has been conducted for M20 concrete making use of ISI method of mix design using normal constituents of concrete. In the course of investigation normal granite aggregate has been replaced by light weight aggregate namely (cinder) in percentages of 0, 25, 50, 75 and 100. Five different mixes which are chosen as follows (Table 2). The Procedure for preparation of Concrete Cubes by Hand Mixing is as follows:

- Cement and fine aggregate were mixed on a water tight none-absorbent platform until the mixture is thoroughly blended and is of uniform color.
- Coarse aggregate were added to it and mix until the coarse aggregate is uniformly distributed throughout the batch.
- At last water is added and mixed it until the concrete appears to be homogeneous and of the desired consistency.

S.NO	Name of the mix	Replacement of coarse aggregate by volume		No. of specimens cast
		Natural aggregate	Coarse aggregate	
1	C-0	100	0	5
2	C-25	75	25	5
3	C-50	50	50	5
4	C-75	25	75	5
5	C-100	0	100	5
Total				25

Table 2: Concrete mixes used in the study

To ensue with the experimental agenda primarily steel moulds of size 150 x 150 x 150 mm were cleaned and brushed with machine oil on all inner faces to make possible easy removal of specimens afterwards. First fine aggregate and cement were added and mixed thoroughly and then conventional coarse aggregates with partially replaced Cinder was mixed with them. By hand mixing all of these materials were mixed thoroughly and apiece 3 number of cubes, 12 number of DCN specimens and 6 number of cylinders were cast. The notch depths afforded were 45mm, 60mm, 75mm and 90 mm running all over the width of the specimen.

Values of a / w ratio = 0.3, 0.4, 0.5, and 0.6

Where, 'a' is the notch depth and
'w' is the specimen depth 150mm.

The distance and width between the notches is kept constant at 50 mm and 2 mm respectively. The two supports in the form of square steel bars were formed throughout the width of the specimen slightly away from the notches. The load was applied within the notches.

However the specimens were demoulded after 24 hours of casting and were kept immersed in a clean water tank for curing. After 7 and 28 days of curing the specimens were taken out of water and were allowed to dry under shade for few hours.

ii. TESTING PROCEDURE

ii a. Test for measuring workability

For checking the consistency of workability standard tests like slump and compaction factor were conducted and with the addition of super plasticizer workability is maintained more or less constant. Hundred percent compaction of concrete is an important parameter for contributing to the maximum strength as shown in and Lack of compaction will result in air voids whose damaging effect on strength and durability is equally or more predominant than the presence of capillary cavities.

S.NO	% of cinder used in concrete	Slump value in mm
1	0	89
2	25	79
3	50	100
4	75	117
5	100	124

Table 3: Test Conducted on Slump Values

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The above table showing the slump values of concrete when using different percentages of cinder. In this we are observing the slump values of concrete is increased with increase in cinder percentage.

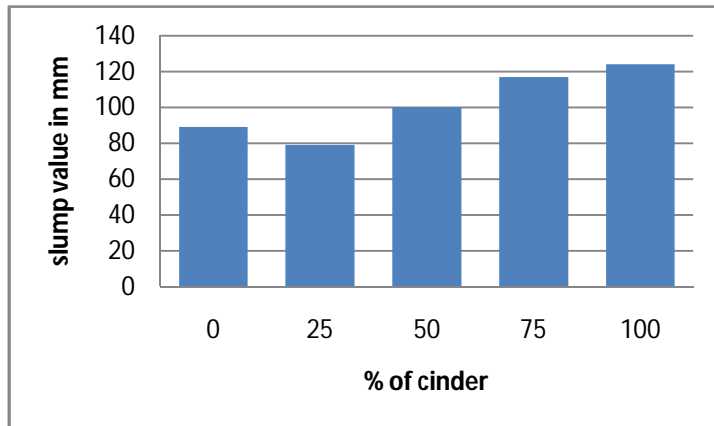


Fig. 2 Graph showing relation between Slump Values and Percentage of cinder

In the above graph the slump of concrete is increased with increase of cinder percentage. The percentage of cinder using in this 0%, 25%, 50%, 75%, 100%.

S.NO	% of cinder used in concrete	Compaction factor value in mm
1	0	0.97
2	25	0.95
3	50	0.94
4	75	0.89
5	100	0.87

Table 4: Test Conducted on Compaction Factor Values

The above table showing the compaction factor values of concrete when using different percentages of cinder. In this we are observing the compaction factor values of concrete is decreased with increase in cinder percentage.

IV. RESULTS AND DISCUSSIONS

i. Testing of cube for compressive strength:

All the concrete specimens were tested in a 200 tones capacity of compression testing machine by meeting the requirements to IS 516:1959 [9]. Concrete cubes of sizes 150mm x 150mm x 150 mm were tested for crushing strength, crushing strength of concrete was determined by applying load at the rate of 140 kg/sq.cm/minute till the specimens failed. The maximum load applied to the specimens was recorded dividing the failure load by the area of specimens ultimate compressive strength was calculated. The geometry of the DCN specimen have shown in figure 3. The formula used to calculate the compressive strength is as follows:

$$\text{Compressive Strength} = \frac{\text{load}}{\text{area}} \text{ N/mm}^2$$

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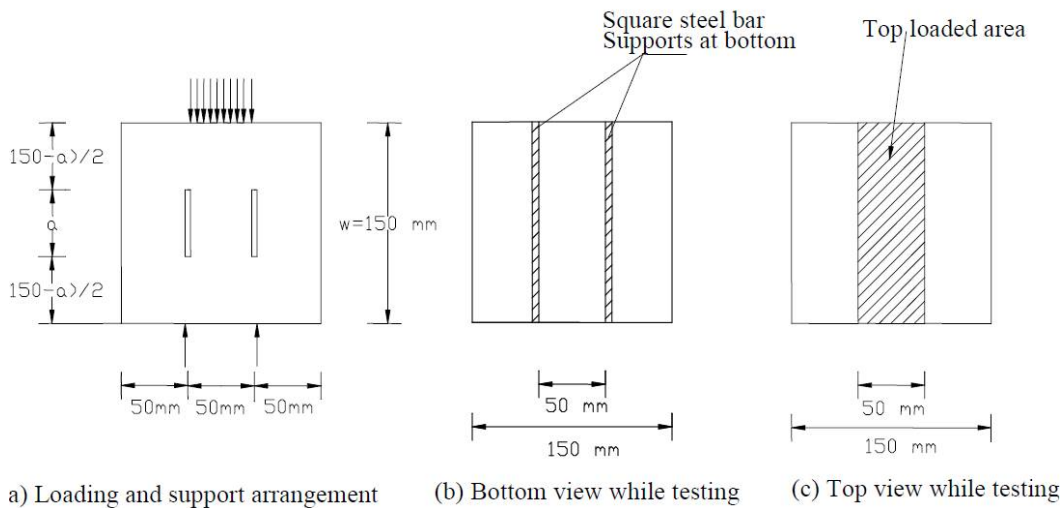


Fig. 3 Geometry of DCN Test Specimen

Out of many test applied to the concrete, this is the utmost important which gives an idea about all the characteristics of concrete. By this single test one judge that whether Concreting has been done properly or not. For cube test two types of specimens either cubes of 15 cm X 15 cm X 15 cm or 10cm X 10 cm x 10 cm depending upon the size of aggregate are used. For most of the works cubical moulds of size 15 cm x 15cm x 15 cm are commonly used. This concrete is poured in the mould and tempered properly so as not to have any voids. After 24 hours these moulds are removed and test specimens are put in water for curing. The top surface of these specimens should be made even and smooth. This is done by putting cement paste and spreading smoothly on whole area of specimen. The compressive strength of concrete is one of the most important and useful properties of concrete, in most structural application concrete are implied primarily to resist compressive stress. In this experimental investigation, plain cement concrete and cinder at 7 and 28 days cubes are used tested for compressive strength. The load at which the control specimen ultimately fails is noted. Compressive strength is calculated by dividing load by area of specimen as shown in Fig.4.

S.No	Name of the Mix	Replacement of Coarse Aggregate by Volume %		Compressive Strength (N/mm ²)	
		Natural Aggregate	Cinder Aggregate	7 days	28 days
1	C-0	100	0	24.22	42.00
2	C-25	75	25	22.90	30.00
3	C-50	50	50	22.20	27.00
4	C-75	25	75	21.70	21.00
5	C-100	0	100	20.00	20.00

Table. 5 Compressive strength results on cube specimen for 7 days & 28 days.

The above table shows the compressive strength of concrete for 7 days and 28 days. Here we are observing the 7 days Compressive strength and 28 days compressive strength is decreased with increase of cinder percentage.

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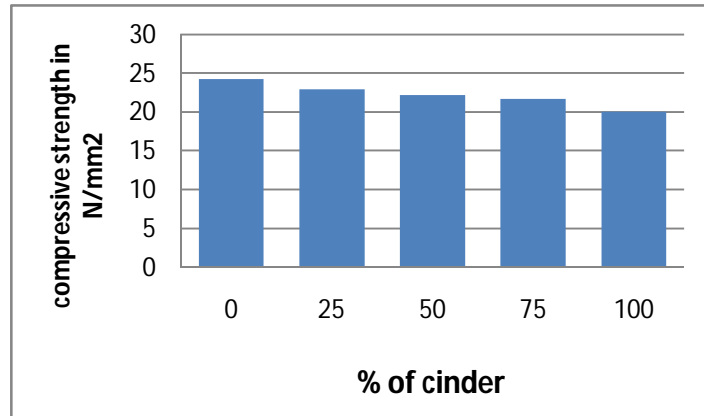


Fig. 4 Graph showing variation between compressive strength Vs % of Cinder aggregate for 7 days

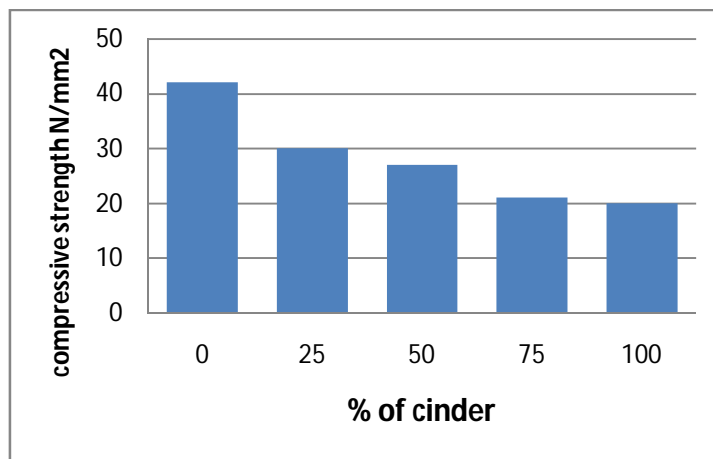


Fig. 5 Graph showing variation between cube compressive strength Vs % of Cinder aggregate for 28 days

ii. Testing of cylinders for split tensile strength:

This test was conducted in a 200 tonnes capacity of compression testing machine by placing the cylindrical specimen of the concrete horizontal, so that its axis is horizontal between the plates of the testing of specimens. Narrow strips of the packing material i.e., ply wood was placed between the plates and the cylinder, to receive the compressive stress. The load was applied uniformly at a constant rate.

Load at which the specimens failed was recorded and the splitting tensile stress was obtained using the formula based on IS 5816:1970 [10].

$$F1 = 2P/\pi DL$$

Where p = Compressive load on cylinder

L = Length of cylinder

D = Diameter of the cylinder

The cube and cylindrical specimen is kept vertically between the compressive plates of the testing machine. The load is applied uniformly until the specimens fails, and ultimate loads are recorded. The test results of cube and cylinder compressive strengths are furnished in table 2 and 3 respectively. This test setup is presented in plate 2 & 4 respectively. An attempt to find out the modulus of elasticity has been done by the 3000KN automatic compression testing machine with 0.5KN/sec rate of loading. The results of modulus of elasticity are furnished in table no 6. The cylindrical specimen was kept horizontally for finding the split tensile strength.

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S.No	Name of the mix	Percentage volume replacement of coarse aggregate (%)		Split tensile strength (N/mm ²)	Percentage of Increase or Decrease in split tensile strength
		Natural aggregate	Cinder aggregate		
1.	C-0	100	0	3.58	0.00
2.	C-25	75	25	3.11	-13.13
3.	C-50	50	50	2.93	-18.16
4.	C-75	25	75	2.63	-26.54
5.	C-100	0	100	2.38	-33.52

Table 6. Split tensile strength Values for different cinder mixtures

The above table shows the split tensile strength of concrete for different percentages of concrete. The table also showing the values percentage of increase or decrease of split tensile strength.

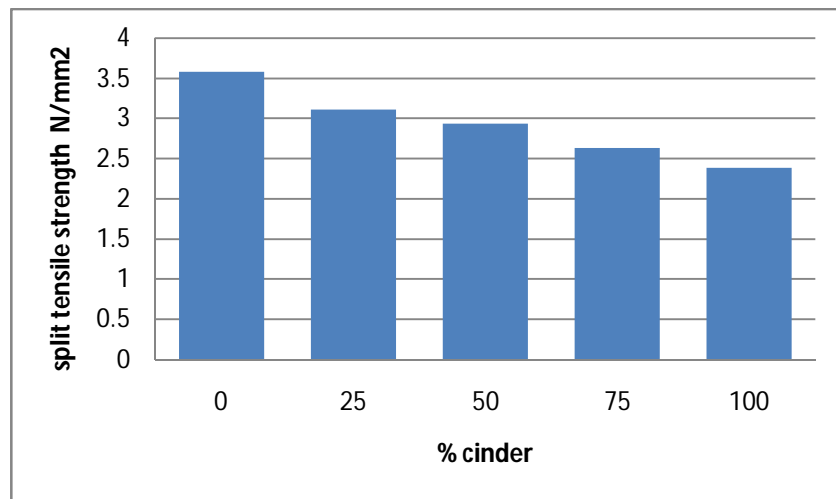


Fig. 6 Graph showing variation between split tensile Vs % of Cinder aggregate

iii. Testing of cylinders for Young's Modulus Analysis:

The slope of the elastic part of the stress-strain curve in tension or compression. The modulus of elasticity of concrete is largely governed by the properties of the coarse aggregate. Increasing the size of coarse aggregates or using stiffer coarse aggregates with a higher modulus of elasticity increases the modulus of elasticity of the concrete. Being a composite material composed of paste and aggregate, the modulus of elasticity of concrete in compression is closely related to the mechanical properties of the paste relative to that of the aggregate particles. It should be noted that while stiffer or denser aggregates improve the elastic modulus of the concrete, they are also capable of introducing stress concentrations at the transition zone and subsequent microcracking at the bond interfaces reducing the ultimate compressive strength capacity of the concrete.

With increase in percentage of replacement of granite by Cinder aggregate, the E value is found to decrease continuously up to 100% as shown in fig 7. The young's modulus (Table 7) is calculated by two approaches. i.e. by I.S.Code method15 and using an empirical formula for light weight concrete 16. The values calculated using both these approaches are observed to match more or less satisfactorily.

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S. No	Name of the mix	Percentage volume replacement of coarse aggregate (%)		Young's modulus $E=5000\sqrt{f_{ck}}$ (N/mm ²)	Young's modulus $E=k_1k_2x1.486x10^{-3}x\sigma_b^{1/2}x\gamma^2$ (N/mm ²) $K_1=0.95, K_2=1.026$
		Natural aggregate	Cinder aggregate		
1.	C-0	100	0	$3.20*10^4$	$3.28*10^4$
2.	C-25	75	25	$2.92*10^4$	$2.93*10^4$
3.	C-50	50	50	$2.76*10^4$	$2.61*10^4$
4.	C-75	25	75	$2.62*10^4$	$2.45*10^4$
5.	C-100	0	100	$2.48*10^4$	$2.15*10^4$

Table 7: Young's Modulus Values for different cinder mixtures

The above table showing the youngs modulus for different percentages of cinder using in concrete.

iv. Testing of cylinders for Density Analysis:

The variation of density and percentage of increase or decrease in density verses percentage of Cinder are shown in fig 7. From the fig. 8, it is observed that with the addition of Cinder the density of the specimens decreases continuously up to 100% replacement of Granite by Cinder, and the values are tabulate in table 8.

S.No	Name of the Mix	Replacement of Coarse Aggregate by Volume %		Density (kg/m ³)	Percentage of Increase / Decrease in Density
		Natural Aggregate	Cinder Aggregate		
1	C-0	100	0	2563	0.00
2	C-25	75	25	2501	-2.42
3	C-50	50	50	2402	-6.28
4	C-75	25	75	2366	-7.69
5	C-100	0	100	2262	-11.74

Table 8. Density Values for different cinder mixtures

The above table showing the density of concrete with different percentages of cinder. The table also showing the percentage increase or decrease in density.

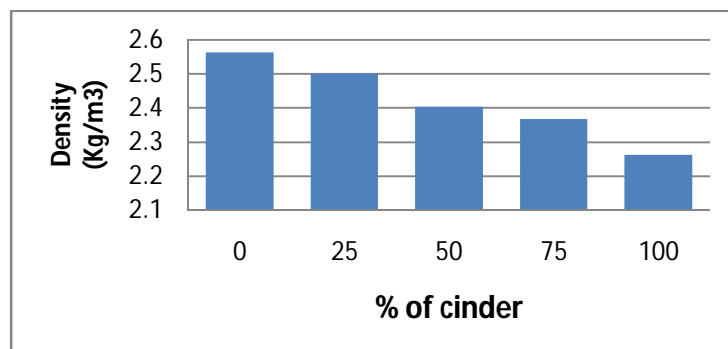


Fig. 8 Graph showing variation between split tensile Vs % of Cinder aggregate

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V. CONCLUSION

This paper demonstrates how the use technology can transform the cause of social and environmental disaster into a natural resource and, hence, can be used in the post disaster rehabilitation construction projects.

This investigation confirmed that the potential use of cinder as an aggregate to produce concrete LWAC will have lower strengths. Based on the results obtained from the experiment the following conclusions are drawn.

1. The cube compressive strength is decreased continuously with the increase in percentage of cinder and also the percentage of decrease in cube compressive strength is increased continuously with increasing cinder. However even with 75% replacement of conventional aggregate by cinder aggregate more than target mean strength of concrete is achieved.
3. The split tensile strength is decreased continuously with increase in percentage of cinder and also the percentage of decrease in split tensile strength is increased continuously with increasing cinder.
4. The young's modulus values have decreased continuously with the increase in percentage of cinder
5. The densities have decreased continuously with the increase in percentage of cinder.

Furthermore the analysis of test results accomplished that the results arrived from IS Code formula is satisfactorily matching with the results arrived from the empirical formula and The cinder aggregate is no way inferior to the natural aggregate.

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