A REVIEW ON EVALUATION OF MECHANICAL PROPERTIES OF HIGH-STRENGTH CONCRETE BY USING FOUNDRY SAND AS PARTIAL REPLACEMENT OF FINE AGGREGATE

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***Abstract:** This study aims at utilization of industrial by product foundry sand for value added application. In addition the waste can improve the properties of construction material. Concrete is a construction material composed of cement, aggregate (fine & coarse aggregate), water and admixtures. Today many researches are on going into the use of fine aggregate replacement, using many waste materials like foundry sand. Foundry sand is high quality silica sand with uniform physical characteristics. Foundry sand consists primarily of silica sand, coated with a thin film of burnt carbon, residual binder (betonies, sea coal, and resins) and dust. Foundry Sand can be used as a partial replacement of fine aggregates as supplementary addition to achieve different properties of concrete. The fine aggregate will be replaced by used foundry sand accordingly in the range of 0%, 20%, 40%, 60% & 100% by weight for M-60 grade concrete. The compressive strength, split tension strength, consistency and flexural strength will be conduct for above replacement. Test results indicated a marginal increase in the strength properties of plain concrete by the inclusion of UFS as partial replacement of fine aggregate (sand) and that can be effectively used in making good quality and economic concrete and construction materials.*

***Keywords-** Metal foundries, Ferrous-nonferrous, Waste foundry sand, compressive strength, splitting tensile strength, modulus of elasticity*

I. INTRODUCTION

Concrete is economical, strong, and durable material. Although concrete technology across the industry continues to rise to the demands of a changing market place. The construction industry recognizes that considerable improvements are essential in productivity, product performance, energy efficiency and environmental performance. The industry will need to face and overcome a number of institutional competitive and technical challenges. One of the major challenges with the environmental awareness and scarcity of space for land-filling is the wastes/by products utilization as an alternative to disposal.

Figure 1 Foundry sand

Foundry industry produces a large amount of by-product material during casting process. The ferrous metal casts in foundry are cast iron and steel, nonferrous metal are aluminum, copper, brass and bronze. Over 70% of the total by- product material consists of sand because molds usually consist of molding sand, which is easily available, inexpensive, resistance to heat damage, easily bonded with binder, and other organic material in mold. Foundry industry use high quality specific size silica sand for their molding and casting process.
This is high quality sand than the typical bank run or natural sand. Foundries successfully recycle and reuse the sand many times in foundry. When it can no longer be reused in the foundry, it is removed from the industry, and is termed as waste foundry sand (**WFS)**. It is also known as spent foundry sand (**SFS**) and used-foundry sand (**UFS**).

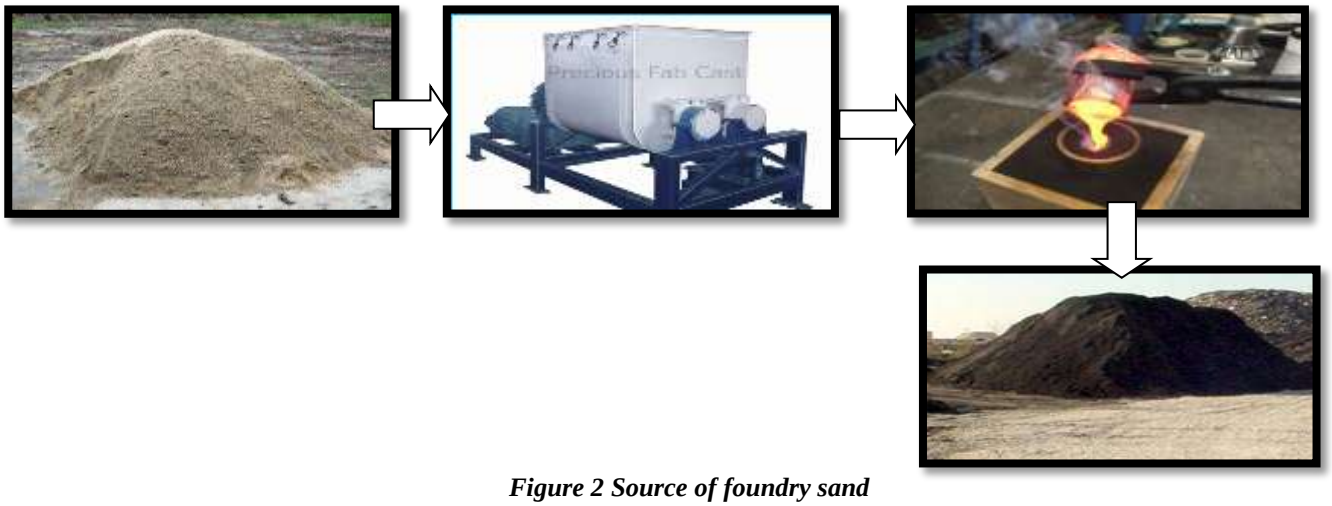


Figure 2 Source of foundry sand

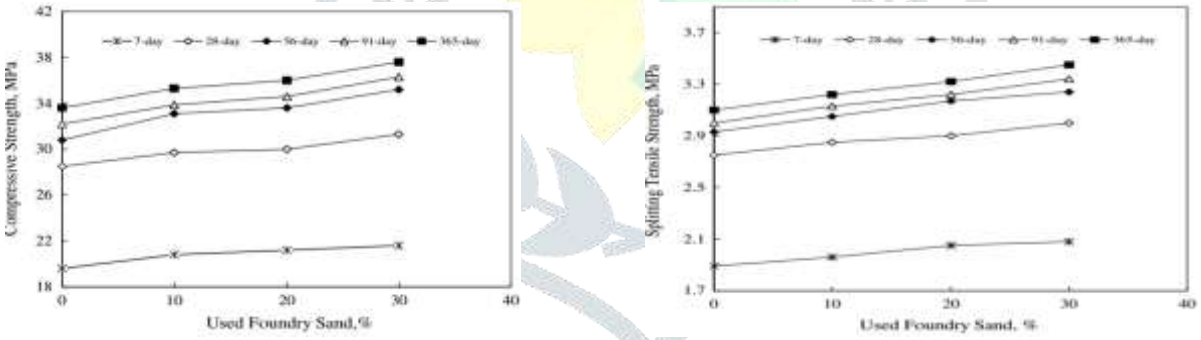
Classification of foundry sand depends upon the type of binder system used in metal casting. Two types of binder systems are used, and on the basis of that foundry sand it categorized clay-bonded sand (green sand) and chemically bonded sand. Green sand is most commonly used molding media by foundries. Green sand is composed naturally occurring materials, which are blended together such as high-quality silica sand (85-95%), bentonite clay (4-10%) as a binder, a carbonaceous additive (2-10%) to improve the casting surface finish and water (2-5%).

II. LITERATURE REVIEW

A. Albert Noumowe, Rafat Siddique Effect of used foundry sand on the mechanical properties of concrete, Construction and building material 23(2009)976-980

Used-foundry sand is a by-product of ferrous and nonferrous metal casting industries. Foundries successfully recycle and reuse the sand many times in a foundry. When the sand can no longer be reused in the foundry, it is removed from the foundry and is termed used/spent foundry sand. In an effort to utilize used-foundry sand in large volumes, research is being carried out for its possible large-scale utilization in making concrete as partial replacement of fine aggregate. This paper presents the results of an experimental investigation carried out to evaluate the mechanical properties of concrete mixtures in which fine aggregate (regular sand) was partially replaced with used-foundry sand (UFS).

Fine aggregate was replaced with three percentages (10%, 20%, and 30%) of UFS by weight. Tests were performed for the properties of fresh concrete. Compressive strength, splitting- Tensile strength, flexural strength, and modulus of elasticity were determined at 28, 56, 91, and 365 days. Test results indicated a marginal increase in the strength properties of plain concrete by the inclusion of UFS as partial replacement of fine aggregate (sand) and that can be effectively used in making good quality concrete and construction materials. Results are as follows:.



(a) **(b)**

Figure 3 (a) Compressive strength (b) splitting-tensile strength, in relation to used foundry sand

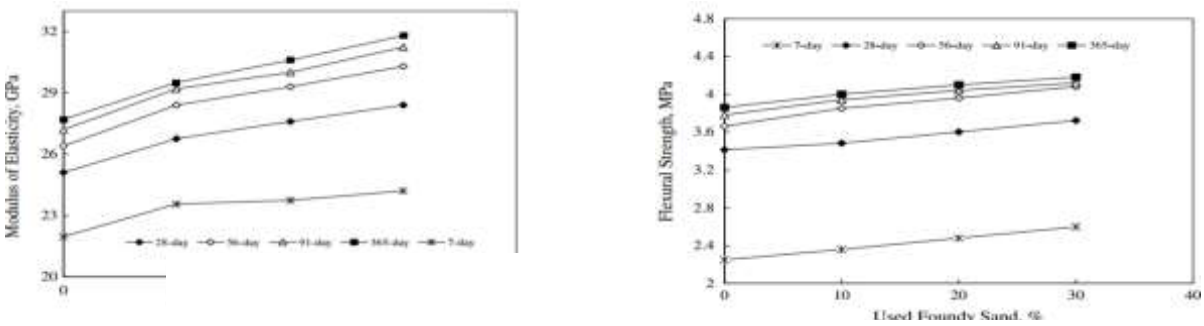
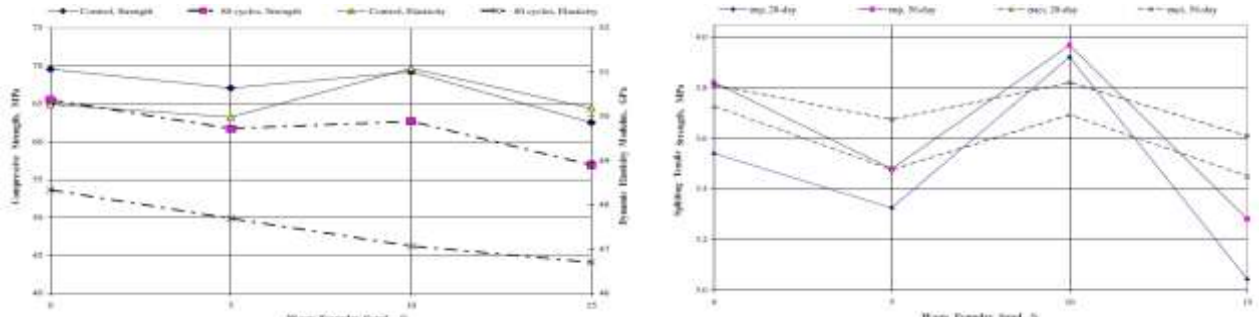


Figure 4 (a) Modulus of elasticity (b) Flexural strength, in relation to used foundry sand

B. acel Guney, Yasin Dursun Sari, and Musin Yalcin Re-use of waste foundry sand in high-strength concrete, Waste Management 30 (2010) 1705-1713

In this study, re-use of waste foundry sand in high-strength concrete production was investigated. The natural fine sand is replaced by waste foundry sand by 0%, 5%, 10%, &15% percentage. The test result shows that reduction in compressive and tensile strength and elasticity modulus which is directly related to percentage of waste foundry sand in concrete. The slump and workability of the fresh concrete decrease with increase of the waste foundry sand ratio. And the freezing and thawing significantly reduces the mechanical and physical properties of the concrete.



(a) **(b)**

Figure 5 Effect of WFS content on (a) Compressive strength & Modulus of elasticity (b) Splitting tensile strength

C. Rafat Siddique, Gurdeep Kaur, Anita Rajor Waste foundry sand and leachate characteristics, Resource, Conservation and Recycling 54 (2010) 1027-1036

Solid waste management has become one of the global environmental issues, as there is continuous increase in industrial by-products and waste materials. Due to lack of land filling space and its ever increasing cost, utilization of waste material and by-products has become an attractive alternative to disposal. Waste foundry sand (WFS) is one of such industrial by-product which could be used in various applications including construction materials such as Controlled Low-Strength Material (CLSM) and concrete. The beneficial use of such by-products in construction materials results in reducing the cost of construction materials' ingredients and also helps in reducing disposal problem.

The leach ate obtained from such materials may contain hazardous compounds, which may possibly effect the environment. So, it is important to know the characteristics of leach ate obtained from waste foundry sand. Understanding the leach ate characteristics offsets essential in its disposal, environmental impact, and potential

development for beneficial utilization towards solid waste management. This paper describes the physical, chemical properties of WFS, various leaches ate test methods, and research published on leach ate characteristics of waste foundry sand.

III. EXPERIMENAL INVESTIGATION

A. Materials

Cement: Ordinary Portland cement (Ultra tech cement) of 53 grade confirming to IS: 12269-1987 was used. It was tested for its physical properties as per IS 4031 (part II)-1988.

Aggregate: The size, shape and gradation of the aggregate play an important role in achieving a proper concrete. The flaky and elongated particles will lead to blocking problems in confined zones. The sizes of aggregates will depend upon the size of rebar spacing. The coarse aggregate chosen for Concrete was typically angular in shape, well graded, and smaller than maximum size suited for conventional concrete; typical conventional concrete should have a maximum aggregate size of 20mm. Gradation is an important factor in choosing a coarse aggregate. Gap-graded coarse aggregate promotes segregation to a greater degree than the well graded coarse aggregate. **Fine Aggregate**: The locally available river sand was used as fine aggregate in the present investigation. The sand was free from clayey matter, salt and organic impurities. The sand was tested for various properties like specific gravity, bulk density etc., and in accordance with IS 2386-1963.

Coarse Aggregate: Machine crushed angular granite metal of 12.5mm nominal size from the local source was used as coarse aggregate. It was free from impurities such as dust, clay particles and organic matter etc. The physical properties of coarse aggregate were investigated in accordance with IS 2386 -1963.

Waste Foundry Sand: Waste foundry sand was obtained locally from Shivshakti foundry Vapi. WFS was used as a partial replacement of fine aggregate (natural river sand). Metal poured in the foundry is gray iron. The sand was tested for various properties like specific gravity, bulk density etc., and in accordance with IS 2386-1963. The fine aggregate was conforming to standard specifications.

Water: Locally available water used for mixing and curing which is potable and is free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete or steel.

Super Plasticizer: Super plasticizer conforming to IS- 9103-1979 by trade name AUROMIX 300 was used to achieve the required workability.

B. Mixes

The present experiment is carried out to investigate strength properties of concrete mixes of grade M60 in which fine aggregate (river sand) is to be partially replaced with Waste Foundry Sand. Fine aggregate will be replaced with 0%, 10%, 20%, 40%, 60% of WFS by weight.

C. Mixing, Casting, Curing and Testing

All the triple blended composites were mixed in the pan mixer. Required number of specimens for various combinations was cast. Continuous curing was maintained up to the age of 7& 28 days. Mixing, casting, curing and testing were carried out as per the standard specifications.

IV. RESULT & DISCUSSION

The study was conducted to find out the influence of waste foundry sand on strength properties of plain concrete. The effects of following parameters were studied. Compressive strength, Split tensile strength and flexural strength at various percentage replacement of fine aggregate with waste foundry sand of high strength concrete.

i. Workability: The dosage of super plasticizer was kept constant throughout the experimental program. As the waste foundry sand percentage increased in the concrete the workability was reduced. This may be due to the void filling action of the waste foundry sand as it is finer than the fine aggregate, which gives a high cohesion to the mix. Mix with increase in waste foundry sand content tends to become harsh, sticky and stiff.

ii. Compressive Strength: Cube specimens was tested for compression and ultimate compressive strength was determines from failure load measured using compression testing machine. The average value of compressive strength of 3 specimens for each category at the age of 7 days, 28 days are tabulated in the Table 1.

Table. 1 Compressive strength test results @7days

Grade of concrete	% of WFS	Load (KN)	Strength(N/mm^2)
M**60**	**0%**	1413.9	62.84
	10%	1599.07	71.07
	20%	1280.25	56.9
	40%	955.35	42.46
	60%	828.67	36.83

Table. 2 compressive strength test results @28days

Grade of concrete	% of WFS	Load (KN)	Strength(N/mm^2)
M**60**	**0%**	1749.6	77.76
	10%	1820.03	80.89
	20%	1339.2	59.52
	40%	1081.8	48.08
	60%	915.75	40.7

There is a considerable improvement in the compressive strength of concrete with inclusion and increase in the percentage of waste foundry sand up to 10%. However on replacement of 20% aggregate the concrete showed marginal decrease in strength.

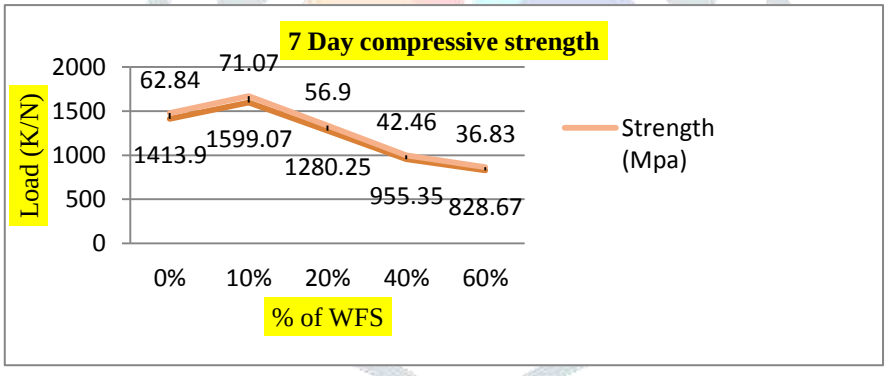
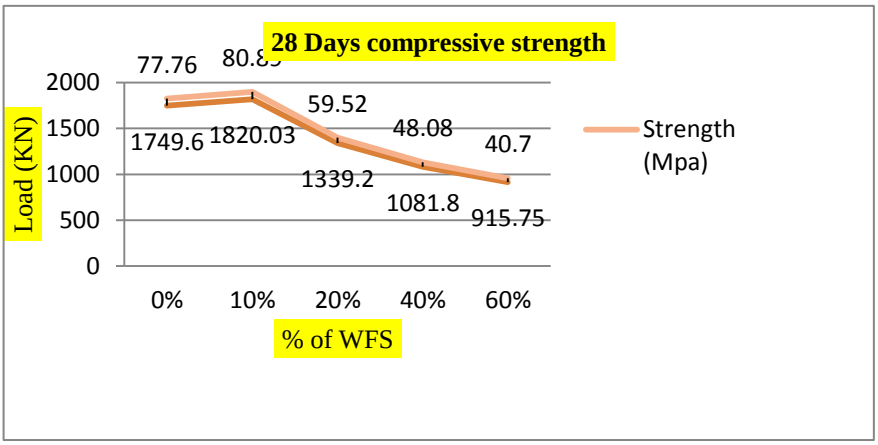


Figure 6 Compressive strength test result @7days

Figure 7 Compressive strength test result @28days



iii. Split Tensile Strength: Cylinder specimens were tested for splitting tensile strength. The test was carried out according to IS: 5816-1970(10). In this test compressive line loads were applied along a vertical symmetrical plane, which causes splitting of specimen. The average values of 3 specimens for each category at the ages of 7 & 28 days are tabulated in the Table 3. The increase in the splitting tensile strength of various concrete mixtures over phigh strength concrete is also tabulated in Table 3. There is a considerable improvement in the split tensile strength of concrete with inclusion and increase in the percentage of waste foundry sand up to 20%.

Table. 3 Split tensile strength test results @7 & 28days

SPLIT TENSILE STRENGTH OF CONCRETE M_{60} GRADE					
SR.NO.	PROPORTION	7-DAYS STRENGTH (Mpa)		28-DAYS STRENGTH (Mpa)	
		INDIVIDUAL	AVERAGE	INDIVIDUAL	AVERAGE
1	M0	2.61	2.65	2.58	2.88
		2.78		3.10	
		2.56		2.97	
2	M1	2.80	2.89	3.47	3.33
		3.07		3.32	
		2.80		3.21	
3	**M2**	**3.46**	**3.37**	**3.80**	**3.80**
		3.315		**4.11**	
		3.33		**3.5**	
4	M3	2.79	2.52	2.91	3.02
		2.35		3.09	
		2.41		3.06	

However on replacement of 30% fine aggregate the concrete showed marginal decrease in strength. It is observed that the split tensile strength increased with increasing age of curing.

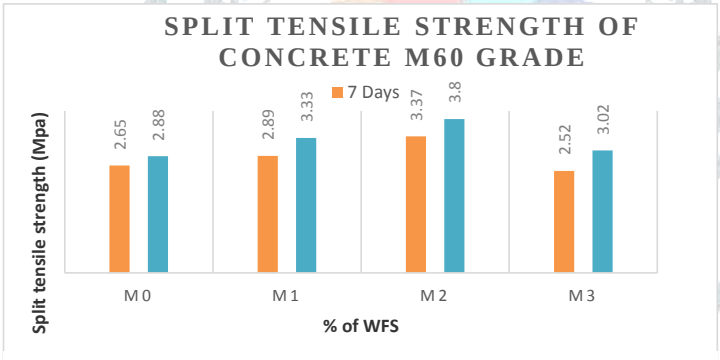


Figure 8 Split tensile strength test result @7 & 28days

iv. Flexural Strength: The tests were carried out confirming to IS: 516-1959(8). The specimens are tested under two-point loading. The average value of 3 specimens for each category at the age of 28 days is tabulated in the Table 4. There is considerable increase in the flexural strength of concrete with the inclusion and increase in the percentage of waste foundry sand up to 10%.

Table. 4 Flexural strength test results @7 & 28days

FLEXURAL STRENGTH OF CONCRETE M_{60} GRADE					
SR.NO	PROPORTION	7-DAYS STRENGTH (Mpa)		28-DAYS STRNGTH (Mpa)	
		INDIVIDUAL	AVERAGE	INDIVIDUAL	AVERAGE
1	M0	4.77	4.76	6.01	6.16
		5.258		6.26	
		4.27		6.19	
2	**M1**	**6.38**	**6.18**	**9.6**	**8.35**
		6.52		**7.1**	
		5.65		**8.34**	
3	M2	5.30	5.13	5.26	5.61
		5.19		6.01	
		4.91		5.57	

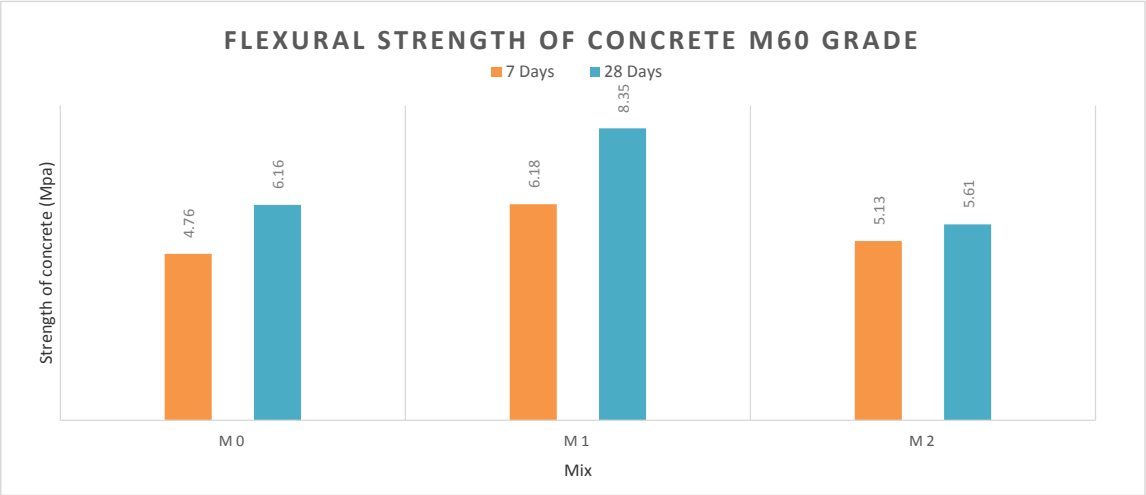


Figure 9 Flexural strength test result @7 & 28days

V. CONCLUSION

From the above literature we conclude that

1. Waste foundry sand can be used as a partial replacement for regular sand in making concrete or concrete products.
2. Compressive strength increases on increase in percentage of waste foundry sand as compared to traditional concrete.
3. In this study, maximum compressive strength and flexural strength is obtained at 10% replacement of fine aggregate by waste foundry sand.
4. Split tensile strength increase on increase in percentage of waste foundry sand up to 20%.
5. As the percentage of WFS increased slump value decreased from 140mm to 40mm.
6. The problems of disposal and maintenance cost of land filling is reduced.
7. Application of this study leads to development in construction sector and innovative building material.
8. Use of waste foundry sand in concrete reduces the production of waste through friendly building material.

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