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Enhancement of Concrete Properties by Replacing Cement and Fine Aggregate with Ceramic Powder

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Abstract—*Ceramic materials contribute the highest percentage of wastes in construction industries. In the ceramic industry, about 15%-20% production goes as waste. The current option for disposal of ceramic wastes is filling of land. This is due to unavailability of standards, avoidance of risk, lack of knowledge and experience in using ceramic wastes in construction. It is well known fact that ceramic waste can be used as a pozzolanic material. This ceramic waste is used to make M-30 grade concrete partial replacement with cement and fine aggregate. The waste of ceramic is available with different properties. In this research we have used of diverse ceramic waste received in different forms like wall tiles ceramic waste powder, vitrified ceramic waste powder and glossy tiles ceramic waste powder, received from different ceramic industries. This ceramic waste is added in range of 0%, 10%, 20%, 30%, and 40% by weight for M-30 grade concrete as partial replacement of cement and in range of 0%, 10% and 20% by weight for M-30 grade concrete as partial replacement of fine aggregate and results are compared with M30 grade concrete made with OPC for 7 days 14 days and 28 days. It was observed that replacement of cement up to 30% and replacement of fine aggregate up to 10% gives desired strength of M-30 grade concrete and gives economic and environmental advantages, use of this waste reduction in the number of natural spaces employed as refuse dumps.*

1. INTRODUCTION

Indian ceramics production is 110 Million tons per year. In ceramics industry, about 15%-20% waste material produced from the total production. Presently large amounts of Ceramic waste are generated in ceramic industries with an important impact on the environment and humans. The utilization of the replacement materials offers cost reduction, energy savings, arguably superior product and pollution reduction in the environment. Fly ash and others are pozzolanic materials because of their reaction with lime liberated during the hydration of cement. These materials can also improve the durability of concrete and the rate of gain in strength and can also reduce the rate of liberation of heat, which is beneficial for mass concrete. The cost of concrete also reduces by using of this kind of replacement material.

2. RESEARCH AIM

The main objective of this study was to develop M30 grade concrete by using of different type of ceramic waste powder like wall tiles ceramic powder, vitrified tiles ceramic powder, glossy tiles ceramic powder in replacement of cement in different proportion i.e. 10%, 20%, 30%, and 40%. And fine aggregate is replaced by floor tiles ceramic powder in 0%, 10% and 20%. The tests were carried out on 7, 14 and 28 days to find out the compressive strength of the cube as per IS-516:1989.

3. MATERIAL USED

There are various types of ceramic waste powder available with different properties. There are some few materials such as cement, fine aggregate, coarse aggregate, wall tiles ceramic powder, vitrified tiles ceramic powder, glossy tiles ceramic powder, floor tiles ceramic powder, water, superplasticizer that are used in this project in making of M-30 grade concrete.

Cement

The ordinary Portland cement (OPC) of 53 grade conforming to IS:8112 used. The chemical property of cement is as per table-1.

Table 1: Chemical property of OPC

Compound	Content, %weight
SiO2 (Silicon dioxide)	24.41
Al2O3 (Aluminum oxide)	5.65
Fe2O3 (iron oxide)	3.62
CaO (Calcium oxide)	59.15
MgO (magnesium oxide)	1.18
P2O5 (phosphorus pentoxide)	0.31
K2O (potassium oxide)	0.54
Na2O (sodium oxide)	0.47
SO3 (sulfur trioxide)	2.64

SrO2 (strontium peroxide)	0.017
Mn2O3 (manganese oxide)	0.43
L.O.I	1.31

Ceramic Waste Powder

Ceramic waste powder is wastage of ceramic industries. It is produce in different form and in various property. Chemical property of ceramic waste is as per table-2 and physical property of ceramic waste is as per table-3.

Table 2: Chemical Compound of ceramic waste powder

Compound	Content, % weight		
	Wall tiles ceramic powder	Vitrified tiles ceramic powder	Glossy tiles ceramic powder
P2O5	2.40	5.60	2.60
CaO	5.61	15.20	22.32
MgO	0.70	1.67	1.67
SiO2	87.20	72.09	68.09
Al2O3	1.45	3.10	2.20
Fe2O3	0.36	2.08	2.08
L. O. I.	1.08	1.91	1.11

Table 2: Physical property of ceramic waste powder

Property	Wall tiles ceramic powder	Vitrified tiles ceramic powder	Glossy tiles ceramic powder
Particle size	≤ 90µ	≤ 90µ	≤ 90µ
Blaine Fineness (cm2/gm)	1500-1800	2000-2200	2500-3000

Fig. 1: Ceramic waste powder, source: AGL

Fine Aggregate

The particle is of such size between 4.75 mm to 90 microns are use as fine aggregate. As per IS-383(1970), the sand obtained from local river is used. It should be properly washed and tested by physical properties.

Coarse Aggregate

The particle size of 10 mm and 20 mm are used as per IS-383(1970).

Super Plasticizer

We had used sikament FF super plasticizer. By substantial improvements in workability without increased water or the risk of segregation. Relative density of this chemical is 1.250. pH value is 8-12.

4. MIX DESIGN

M-30 Grade concrete was designed as per IS-10262-2009. The same design used for various sample of replacing material concrete.

Table 3 Mix Proportion for M-30 Grade concrete

No.	Parameters		Value
1	Cement content		380kg/m3
2	Water cement ration		0.42
3	Fine aggregate		761kg/m3
4	Coarse aggregate	10mm	359 kg/m3
		20 mm	924 kg/m3
5	Super-Plasticizer		0.5 %
6	Water content		160 L

Mix proportion – C: FA: CA – 1: 2.01: 3.37

The mixture of concrete contains cement, sand, aggregate, water, super plasticizer. Cement is replaced in range of 10%, 20%, 30%, 40% by wall tiles ceramic powder, vitrified tiles ceramic powder, glossy tiles ceramic powder. Sand is replaced in range of 0%, 10%, 20% by floor tiles ceramic waste powder.

5. DISCUSSION OF RESULT

A compression testing machine of 2000KN load was used to find out the compressive strength of normal concrete and replacement of cement by ceramic waste concrete at the end of 7 days, 14 days and 28 days. Moulds of size 150mm×150mm×150mm were filled with concrete and curing. In compressive strength test, load of 5.2 kN/s is applied on the cubes.

Replacement of cement with CP1 (Wall tiles ceramic powder)

C11 - Cement replace with CP1 by 10%.
C12 - Cement replace with CP1 by 20%.
C13 - Cement replace with CP1 by 30%.
C14 - Cement replace with CP1 by 40%.

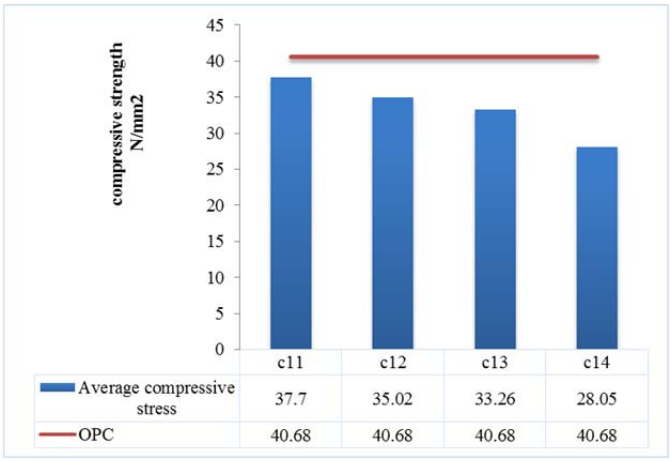

Fig. 2: Compressive Strength comparison @ 28day

From the above Fig. it is observed that the replacement of cement with wall tiles ceramic powder up to 30% getting the characteristic strength at the age of 28 days. The strength of concrete at 30% replacement, the cost reduces up to 25%.

Replacement of cement with CP2 (Vitrified tiles ceramic powder)

C21 - Cement replace with CP2 by 10%.
C22 - Cement replace with CP2 by 20%.
C23 - Cement replace with CP2 by 30%.
C24 - Cement replace with CP2 by 40%.

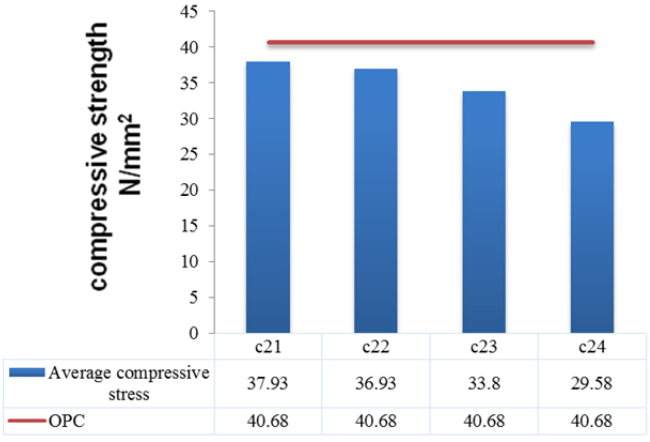

Fig. 3: Compressive Strength comparison @ 28day

From the Fig. 3 it is observed that up to 30% replacement the characteristic strength is getting at the age of 28 days. And up to 20% replacement the target mean strength also achieved.

So the use of vitrified tiles ceramic powder for replacement of cement is better than wall tiles ceramic powder.

And by replacement of this up to 30% cost of concreate can be reduce.

Replacement of cement with CP3 (Glossy tiles ceramic powder)

C31 - Cement replace with CP3 by 10%.
C32 - Cement replace with CP3 by 20%.
C33 - Cement replace with CP3 by 30%.
C34 - Cement replace with CP3 by 40%.

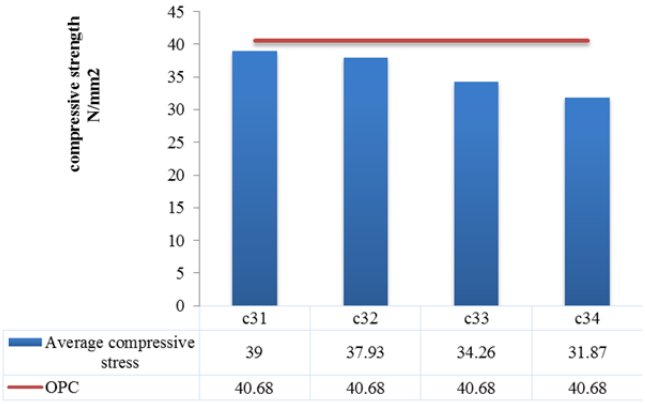

Fig. 4: Compressive Strength comparison @ 28day

From the Fig. it is observed that Replacement of glossy tiles ceramic powder up to 20% getting the target mean strength of M-30 grade concrete at 28 days.it is also observed that the replacement of cement with glossy tiles ceramic powder up to 40% the characteristic compressive strength obtained at the age of 28 days.

Replacement of Fine Aggregate with CP4 (Floor tiles ceramic powder)

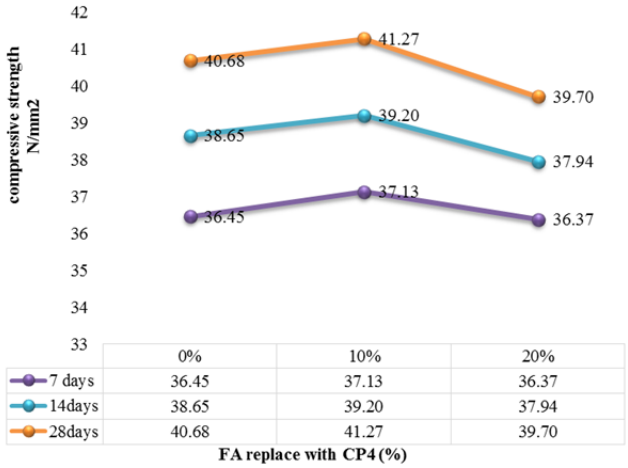

Fig. 5: Compressive strength of FA replace with CP4 @ 28 days

From the Fig. 4 it can be seen that by the 10% replacement of Fine aggregate with floor tiles ceramic powder, the compressive strength increases and further replacement it starts to decrease.

Replacement of cement & FA with CP1 and CP4

C11C41 - Cement replace by CP1 by 10% and FA by 10%
C12C41 - Cement replace by CP1 by 20% and FA by 10%
C13C41 - Cement replace by CP1 by 30% and FA by 10%
C14C41 - Cement replace by CP1 by 40% and FA by 10%

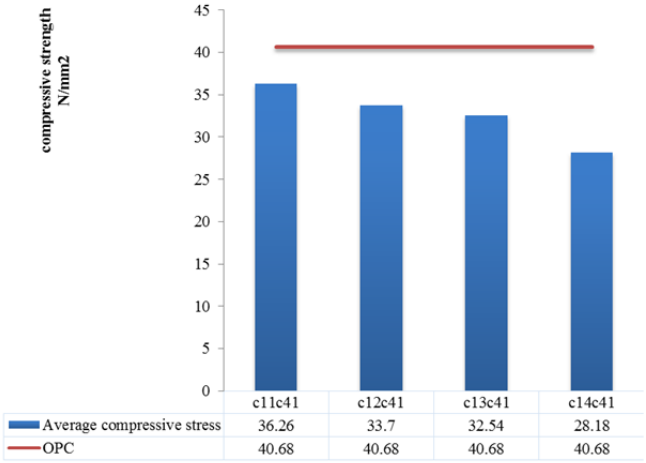

Fig. 6: Compressive Strength comparison @ 28day

By the replacement of cement with wall tiles ceramic powder up to 30% & replacement of FA with floor tiles ceramic powder up to 10%, the characteristic strength obtained.

Replacement of cement & FA with CP2 and CP4

C21C41 - Cement replace by CP2 by 10% and FA by 10%
C22C41 - Cement replace by CP2 by 20% and FA by 10%
C23C41 - Cement replace by CP2 by 30% and FA by 10%
C24C41 - Cement replace by CP2 by 40% and FA by 10%

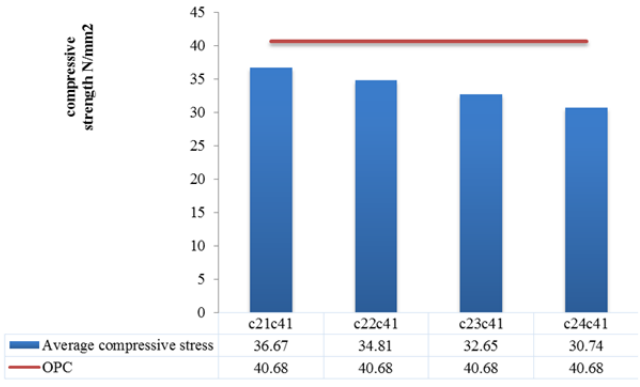

Fig. 7: Compressive Strength comparison @ 28day

Replacement of cement & FA with CP3 and CP4

C31C41 - Cement replace by CP3 by 10% and FA by 10%
C32C41 - Cement replace by CP3 by 20% and FA by 10%
C33C41 - Cement replace by CP3 by 30% and FA by 10%
C34C41 - Cement replace by CP3 by 40% and FA by 10%

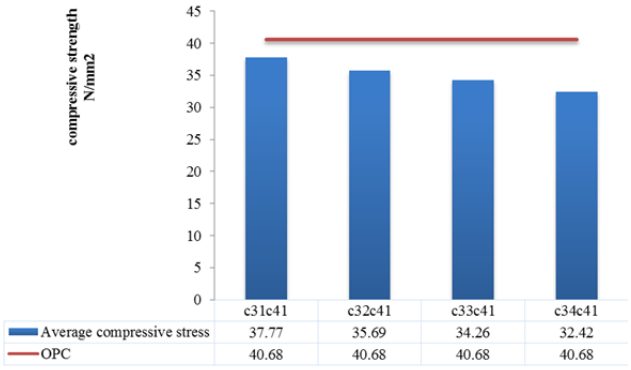

Fig. 8: Compressive Strength comparison @ 28day

From the Fig. 8 it is observed that up to 40% replacement of cement with glossy tiles ceramic powder and 10% replacement of FA with floor tiles ceramic powder gives characteristic compressive strength.

6. CONCLUSION

1. The studies carried out indicated that the compressive strength of M-30 grade concrete increases up to **8%** when the replacement of Fine aggregate with floor tiles ceramic powder up to **10 %**, and at 20% replacement compressive strength reduces but gives target mean strength.
2. By the replacement of cement with glossy tiles ceramic powder up to **20%** gives target mean compressive strength.
3. The characteristic compressive strength of concrete is increases when the replacement of cement up to 30% and vice-versa the cost reduces up to **30%**.
4. By the replacement of cement up to 30% and FA up to 10% with ceramic waste powder, the characteristic compressive strength achieved and other side the cost is reduces up to 33%.
5. By the replacement of FA with ceramic waste powder use of sand can be reducing.
6. It is best alternative solution for reducing the environmental and land pollution.

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