EXPERIMENTAL INVESTIGATION ON PARTIAL REPLACEMENT OF COARSE AGGREGATES BY CERAMIC WASTE AND PARTIAL REPLACEMENT OF CEMENT BY FLY ASH

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Abstract- Natural sand is a standout among the most ordinarily utilized fine aggregate as a part of concrete. Owning to acute shortage of natural sand in many areas and keeping environmental and cost factors into consideration an alternative for the same is pondered. In view of above discussion, an attempt is made to replace the cement and coarse aggregate in concrete of M50 grade with fly ash and ceramic waste to study the workability and compressive strength at 7,14 and 28 days curing periods. According to the results of the experiment, it is concluded that with increase in replacement of fly ash, the maximum compressive strength was obtained in M2 mix at 28 days which was 6.93% more than M0.
In final mixes maximum compressive strength was achieved in M2C1 which was 13.61% more than M0 mix.
Also the unit weight of the specimen decreased by 8% for M2C1therefore it can be used for lightweight concrete.

Keywords- Natural Sand, Fine aggregates, Fly Ash, Ceramic Waste, Coarse aggregates

I. INTRODUCTION

Concrete is a paste of cement, water and aggregates and in some cases rocks. Water and cement mixture coats the surface of the fine aggregates and the coarse aggregates. The paste gets starts gaining strength and gets hardens to form the rock-like mass known as concrete through a process called hydration. Fly ash remains, which is additionally termed as "pulverized fuel ash", is one of the waste buildup produced by coal ignition, and is made out of the fine particles that are driven out of the boiler alongside flue gasses. Ash that settles down the base of the boiler is termed bottom ash.

In the creation of Portland cement concrete fly ash is utilized as a secondary cementitious material (SCM). A secondary cementitious material, utilized as a part of conjunction alongside portland cement, adds to the properties of the solidified concrete through hydraulic or pozzolanic action or both.

A ceramic material may be defined as any inorganic crystalline material, compounded consists of metal and non-metal or metalloid atoms. Ceramic Materials are strong and inert. Ceramic materials are brittle, hard, and solid in pressure, frail in strain and additionally in shearing. They can withstand compound disintegration that happens in an acidic or scathing ‘environment. Ceramics generally can withstand very high temperatures that can go from 1,000 °C to 1,600 °C (1,800 °F to 3,000 °F). Exemptions are there for the inorganic materials which don't have oxygen and in addition silicon carbide.

Table -1 Physical Properties of Cement

GRADE OF CONCRETE	Experimental	43GRADE (As per IS:8112:2013)
MINIMUM SPECIFIC SURFACE (Blaine's air permeability) m^2/kg	200	225
Initial setting time	110 minutes	30 MINIMUM
Final setting time	216 minutes	600 MAXIMUM
Soundness, expansion (mm)	5mm	10 maximum (Le Chatelier Test)
Normal Consistency	32%	-
Compressive Strength		
7 Days	33Mpa	33Mpa
28 Days	43.5Mpa	43Mpa

Table2 – Sieve Analysis of Fine Aggregates

IS Sieve Size	Weight of Aggregate Retained (gms)	Average (gms)	% of total Weight retained	Cumulative % of total Weight retained	% of Passing	Permissible value as per IS:383-1917 (Zone-2)
10mm	0	0	0	0	100	**100**
4.75mm	92	92	9.2	9.2	90.8	**90-100**
2.36mm	53	53	5.3	14.5	85.5	**75-100**
1.18mm	101	101	10.1	24.6	74.8	**55-90**
600 µm	169	169	16.9	41.5	58.5	**35-59**
300 µm	378	378	37.8	79.3	20.7	**8-30**
150 µm	180	180	18.0	97.3	2.70	**0-10**

Table3- Sieve Analysis of Coarse Aggregates

Sieve Size (mm)	Weight of Aggregates retainer (gms)	Avg.	% of total Wt. Retained	Cum. % of Wt. retained	% of passing	Permissible values as per IS 383:1917
20	109	109	10.9	10.9	89.1	85-100
10	852	852	85.2	96.1	14.8	0-20
4.75	39	39	3.9	100	0	0-5
PAN	0	0	0	100	0	-

Materials and Methods

Experimental Study: After proper mixing of ingredients, moulds of size 150mm×150mm×150mm were placed on vibrating machine after proper oiling and securely tighten to correct dimension. Proper care was taken that there is no gaps left from where there is any probability of leakage of concrete paste (slurry). Then the concrete is poured in the moulds in three layers. Each layer is left to vibrate for 8-12 seconds to avoid honey combing and moulds are filled up to the brim. After concreting and compaction upper surfaces made smooth with the help of trowel. The moulds were left undisturbed for 24 hours in the laboratory. A total of 81cubes were casted for the experimental study. All the specimens were casted according to IS 516:1959.

Cement: To prepare mixes, ordinary Portland cement (O.P.C) grade 43 manufactures by shri ultra was used throughout the study. The physical properties of the cement are listed in Table 1. The cement satisfies the requirements of IS 8112:2013.

Fine Aggregates: The fine aggregate which was used was locally available river sand, which passed through 4.75 mm. Result of sieve analysis of fine aggregate is given in Table 2. The specific gravity of fine aggregate is 2.61 and fineness modulus is 2.67. Bulk density of fine aggregates is 1.29.

Coarse aggregate: Crushed stones of size greater than 4.75mm and passing through 20mm sieve conforming to IS 383:1970 were used in the study. Sieve analysis of coarse aggregates is given in Table3. The specific gravity of coarse aggregates is 2.63 and bulk density is 1.5.

Fly Ash: Fly ash supplied by Qasimpur Power House, Aligarh which belongs to class C was used. It is used as partial replacement of cement in concrete mix. Fineness and lime reactivity of Fly Ash was 360m^2/kg and 5.2N/mm^2 respectively.

Ceramic Waste: The waste generated by the ceramic industries is termed as ceramic waste. In this study ceramic waste was collected from various ceramic industries located in Khurja. Specific Gravity obtained was 2.15 whereas water absorption was obtained 0.18%.

Water: Potable water was used for mixing and curing.

Mix Design: Design mix proportion of 1:1.77:2.278 at w/c ratio of 0.35 were used for M50 grade concrete and cement content were 450kg/m^3 satisfying all the basic requirement as per IS:10262-2009.

Table 4 – Replacement percentage of cement and aggregates by fly ash and ceramic waste

S.No	Concrete Mix	Mix Content
1.	M0	M50
2.	M1	M50 + 10% fly ash
3.	M2	M50 + 20% fly ash
4.	M3	M50 + 30% fly ash
5.	M4	M50 + 40% fly ash
6.	M2C1	M50 + 20% fly ash + 10% ceramic waste
7.	M2C2	M50 + 20% fly ash + 20% ceramic waste
8.	M2C3	M50 + 20% fly ash + 30% ceramic waste
9.	M2C4	M50 + 20% fly ash + 40% ceramic waste

***Results and discussions*:**

Fresh property of concrete is determined by Workability of concrete which is one of the main physical parameter which affects the strength and durability as well appearance of the finished concrete and the cost of labor. Workability of concrete is measured with the help of slum test. .The slump flow of M0 was 20mm which is acceptable according to IS 4926:2003. The slump value goes on increasing from M0 to M4 as Fly ash imparts lateral strength as compared to cement which imparts early strength in concrete. According to IS code all the values are within the limiting range. The compression in slump values for initial mixes is shown in Fig.1.1. The slump flow goes on increasing from M2C1 to M2C2 and maximum slump was achieved in M2C4 i.e. 40% replacement of cement by Fly ash and 40% replacement of coarse aggregates by ceramic waste because angular and rough aggregates which results in poor workability are replaced by 40% by ceramic waste which are cubical in shape and smooth in surface. Comparison in slump values for final mixes is shown n Fig.1.2. The overall comparison is shown in Fig.1.3.

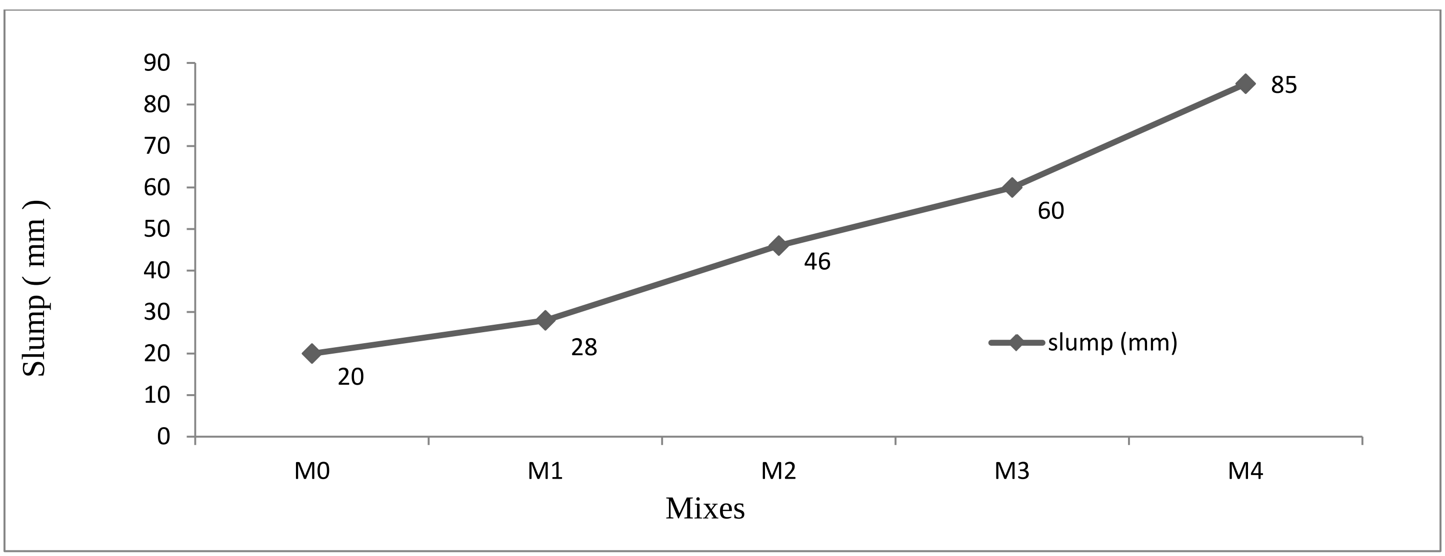

Figure 1.1 Comparison in slump values of initial mixes

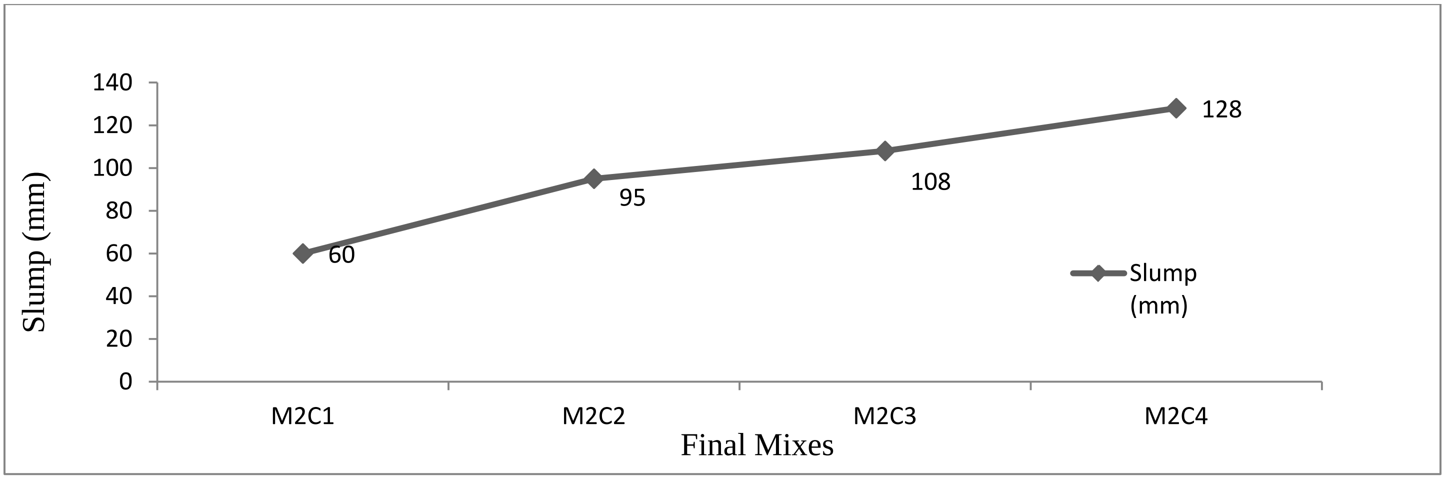

Figure 1.2 Comparison in slump values of final mixes

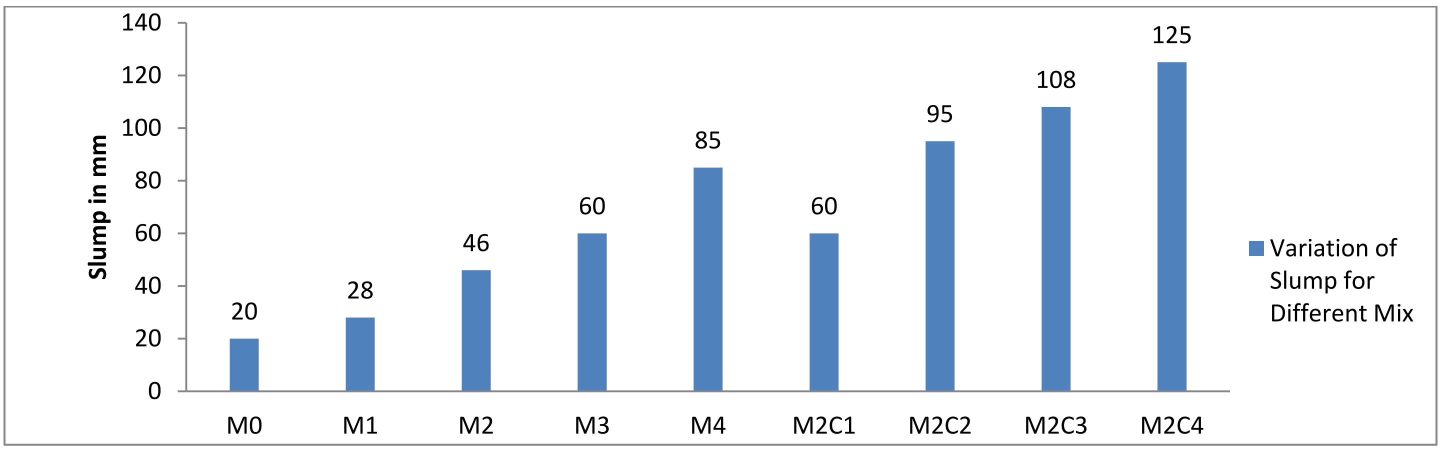

Figure 1.3 Slump values of different mix

After the completion of curing period of 7days, 14days and 28days cubes were tested for their compressive strength with the help of C.T.M, conforming to IS 516:1959.

Cubes were tested immediately after removal from the curing tank. Cubes were placed on the platform of C.T.M. as shown in Figure 4.6 and the load was applied and gradually increased until the specimen is no more able to bear the load and graph shows a decreasing reading. The total load applied at the failure is noted down and this load divided by the area of the specimen gives the compressive strength of the specimen. Average of at least three specimen were taken for each day and results were recoded.

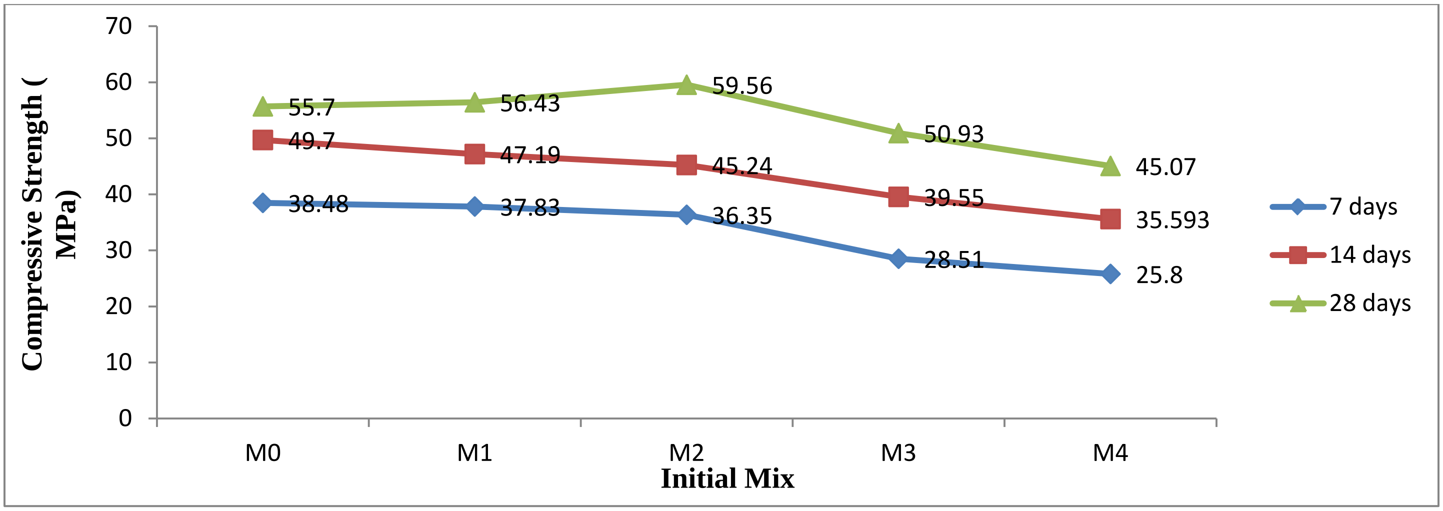

Figure 1.4 Comparison in compressive strength of initial mixes

From the Fig.1.4 it can be observed that the 7days and 14days compressive strength of mixes goes on decreasing from M0 to M4 on replacement of cement by fly ash. As increase in percentage level of fly ash in mix the percentage decrease for 7 days compressive strength was found to be 1.69% to 32.95% for M1to M4 respectively while for 28 days curing period the increase in percentage in compressive strength was observed to be 1.31% and 6.93% for M1 and M2 respectively while percentage starts decreasing as we go to M3 and M4 from 8.56% to 19.04% respectively. This is due to pozzolan and self-cementing property of Fly ash which in case of water hardens and gets stronger over time.

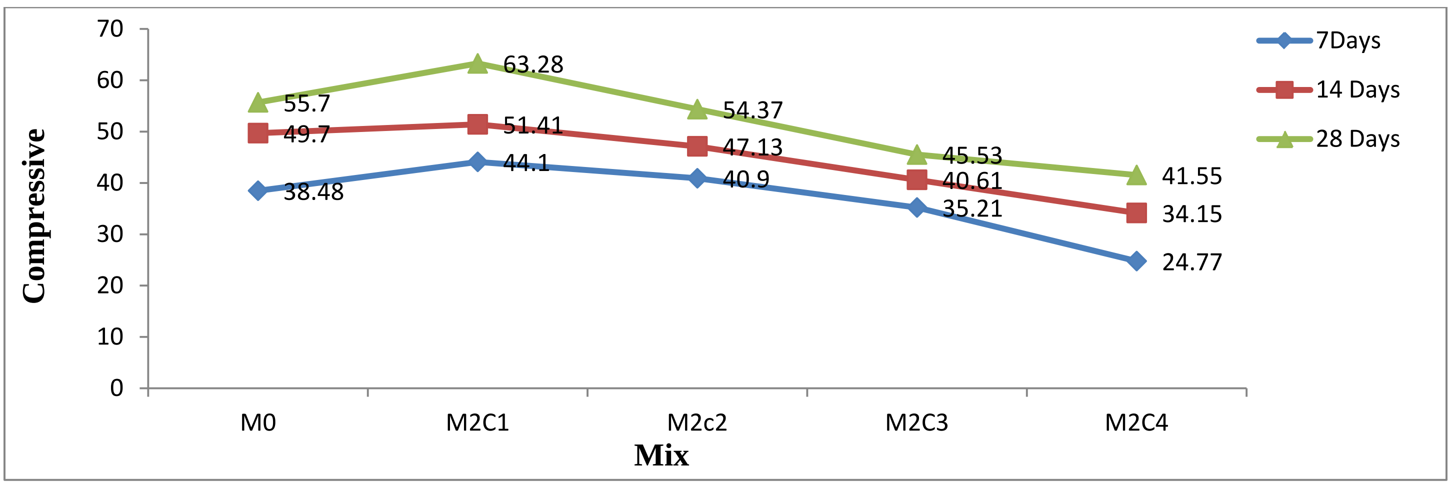

Figure 1.5 Comparison in compressive strength of final mixes.

From Fig.1.5 it can be observed that there is increase in percentage in compressive strength, moving from M0 to M2C1. The increase in percentage is 13.61% after 28 days of curing. In case of other mixes the strength goes on decreasing from 2.388% to 25.40% in M2C2 and M2C4 respectively. The compressive strength goes on decreasing because of the fact that ceramic waste has smooth surface and cuboidal shape which results in less bonding of materials.

On the other hand compressive strength goes on increasing from M0 to M2C1 because the replacement of coarse aggregate was just only 10% and maximum ceramics were indulge in filling the voids present in the coarse aggregates which results in great bonding of materials and hence results in high compressive strength.

Moving from normal M50 grade concrete the weight of concrete goes on decreasing on replacement of cement by fly ash and coarse aggregates by ceramic waste because fly ash is light in weight as compared to cement and ceramic is also light in weight as compared to coarse aggregates which results in light weight cubes. The specific gravity of ceramic waste is less as compared to specific gravity of coarse aggregate while specific gravity of fly ash is less as compared to specific gravity of cement. The comparison in weight of cubes in all mixes is shown below in Fig.1.6.

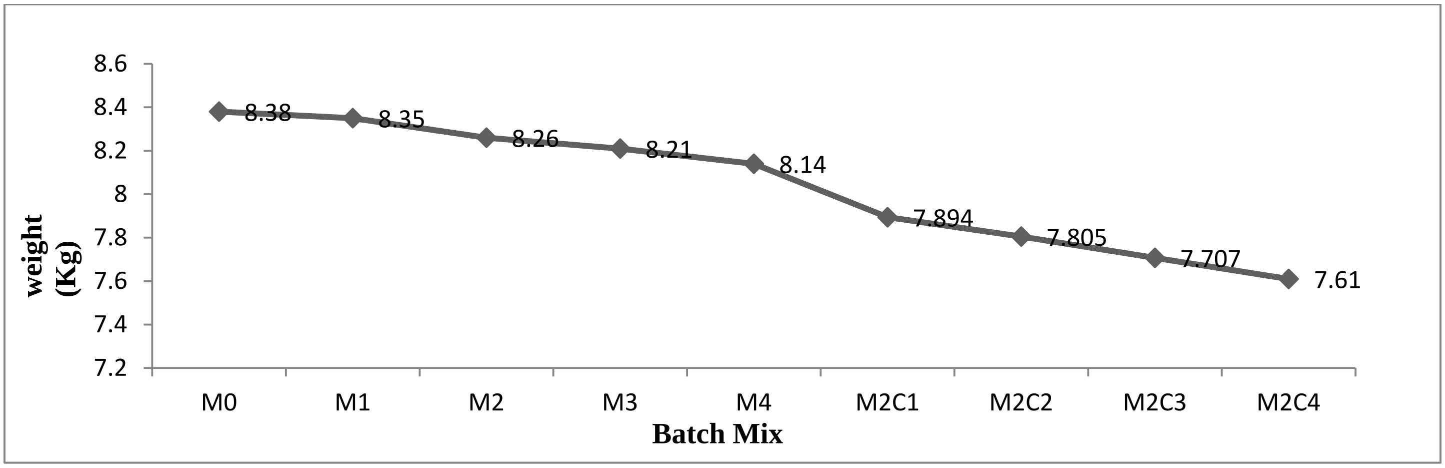

Figure 1.6 Variation of weight after 28 days for all mixes.

Figure 1.6 shows that there was gradual decrease in weight of each cube as we go from M0 to M2C4. The decrease in percentage of unit weight varies from 0.35% to 9.2% per cube from M1 to M2C4 respectively. The maximum compressive strength was attained in M2C1 composition which results in 5.8% decrease in weight per cube as compared to normal mix. The compressive strength was 13.61% more compared to M0, hence it can be used in light weight structures.

Conclusion:

- Based on the work it has been concluded that at 20% replacement of cement by fly ash maximum compressive strength was achieved with reference to standard design mix the compressive strength at 28 days was 6..93% more. The compressive strength goes on increasing from 10% to 20% and above 20% replacement level compressive strength goes on decreasing due to low cement content.
- Workability of concrete goes on increasing from 10% to 40% replacement of cement by fly ash. Maximum workability was attained at 40%.
- Replacement of cement by fly ash also reduces the bleeding of concrete and hence results in improved surface finish.
- At 20% replacement of cement by fly ash, the maximum compressive strength is achieved when crushed 10% coarse aggregates were replaced by crushed ceramic waste. But after that it is decreasing for 20% replacement and so on.
- Specific Gravity of ceramic waste is 2.15, which is 18.25% lower when compared to the specific gravity of coarse aggregate which is 2.63.So ceramic waste satisfied limit of specific gravity as per IS Code. Therefore, the usage of ceramic waste can reduce the dead weight of the structure up to 18.25%.
- In combination, maximum compressive strength was obtained for the mix having 20% replacement of cement by fly ash and 10% replacement of coarse aggregate by ceramic waste which is 13.6% more with reference to standard design mix at 28 days.
- By using the mix M2C2 the mass of cube reduces from 8.38 kg to 7.894kg, which can result in light weight structure as compared to normal concrete.
- The slump value goes on increasing with increase in quantity of Fly ash in M2 the slump value was 130% more than that of M0 and this increase in percentage is up to 325% for M4.
- On replacing coarse aggregates by ceramic waste the slump value goes on increasing from M2C1 to M2C4.The slump value in case of M2C1, for which maximum slump value was obtained was 200%more than that of M0 and this increase in percentage is up to 525% for M2C4.
- Cost of construction can be minimized with usage of fly ash which is cheaply available.

- To realm the saving of environment pollution by cement production, fly ash and by the ceramic waste was the main objective as being a civil engineer.

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