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## Partial Replacement of Fine Aggregate with Ceramic and Demolition Waste in Rigid Pavement

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**ABSTRACT:** In this developing world the day by day increasing demand for natural construction materials for rapid urbanization calls for the necessity for alteration of construction materials. The sources of natural sand and aggregate is reducing day by day and to reduce the production cost of concrete has urged to identify material that can substitute fine aggregates for example demolition and Ceramic Waste in the production of concrete. Demolition and Ceramic Wastes are waste products which are released directly into the environment and can cause environmental pollution. Disposal of waste and to find solution of reusing is one of the most serious problems of the world today. Numerous waste materials are generated from manufacturing processes, service industries, construction and demolition works and municipal solid wastes. The increasing awareness about the environment has tremendously contributed to the concerns related with disposal of these generated wastes. Solid waste management is one of the major environmental concerns in the world and with the scarcity of space for dumping and due to its ever increasing cost; waste utilization has become an attractive alternative to disposal. There are numerous researches that are being carried out to utilize these wastes in the construction industry where most of them are related to using these wastes in concrete. This will lead to utilization of wastes as well as reduction of usage of naturally occurring construction materials which in turn are depleting the natural resources due to the increasing demand of construction materials, meanwhile making concrete economical and also will reduce the disposal problems associated with these waste materials. The base of my work is to make concrete blocks with partial replacement of fine aggregates from ceramic and demolition wastes which can be replaced with the traditional rigid pavements that are used immensely.

**KEYWORDS:** Compressive Strength, Flexural Strength, Demolition Waste, Ceramic Waste

### I. INTRODUCTION

The need of time has urged us to pay an attention to conserve natural resources and to reduce energy used in production and in some part of the world particularly where there is a shortage of natural construction material leads to the need of recycling of Ceramic wastes (cw) and Demolition Wastes (dw) that has been recognized as a standard alternative for both construction and maintenance in some countries. The day by day rising demand of natural sand in developing countries including India is the reason of experiencing scarcity of good quality natural sand. Nowadays the construction industries of these countries are in a way to identify alternatives for the replacement of the natural sand and aggregate. Ceramic Waste as a construction material for partial replacement of fine aggregate in concrete having both benefits and weaknesses, whose use generally increases the drying shrinkage and creep and decreases the compressive strength and modulus of elasticity of concrete compared to those of natural aggregate concrete for which undesirable effects resulting in poor concrete quality push a limit on the use of this material in structural concrete. The above said undesirable effects can be mitigated by incorporating a certain amount of additional additives into the concrete mixture

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like fly ash is known to be able to reduce the creep and drying shrinkage of concrete, and many more other materials having different effects, which is needed to be found out. The recycling of demolition waste as a partial replacement of fine aggregate along with the ceramic waste may lead a way to success and a lot of other environmental impacts like increasing volume of demolition waste and the rapid shortage of dumping site leading to intense growth in transportation and regime cost, drastic environmental pollution may be mitigated here by. Demolition of old structures for adoption of new and modern sophisticated construction for increasing need of comfort leads to the growth of volume of demolition waste due to rapid urbanization in towns and cities. The enforcement of environmental laws had forced aggregate plants to go for the alternative use of demolition waste, which is about 75% of the total mangle wastes. Neoteric research enlightens that broken concrete obtained from dismantled waste can be used to yield recapitulated aggregate which in turn can be used for making new concrete. Demolition waste constitutes finishes, cloddy materials, lumber, dirt, steel, hardware, woods etc. All the undesirable particles can be separated out with the help of jaw crusher, impact hammer, swing crusher etc. For processing of demolition waste we use three processes namely dry, wet, thermal. The classification of aggregates has been given by The Waste & Resources Action Program (WRAP) in the UK as primary, recycled and secondary material resources. Ceramic Wastes encompass industrial by-products and reused construction products, all of which were once considered wastes and dumped in land fill. The recently introduced European Standards for aggregates do not discriminate between different sources, and are for 'aggregates from natural, recycled and manufactured materials'. The focus is on fitness for purpose rather than origin of the resource. The purpose of this report is to review the various sources of aggregate and examine their potential use in concrete and/or road construction materials. Ceramic Wastes are inert materials mostly originated from CDW. In broad terms the CDW can be anything ranging from broken concrete and bricks from demolition sites, excavated materials from foundation work sites to broken up road surfaces resulting from the road maintenance, etc. CDW use is increasing over time, proportionate with the development of the towns and the countries. Reducing, reusing and recycling appear to be the best option, thus, also increasing the lifetime of landfills and reduce exploitation of the natural resources. The earliest data of the applications of Ceramic Waste materials in construction started to the 1920s in Holland, when demolished rubble and slag were processed as aggregates in the so-called gravel concrete used for the residential building construction. At the end of World War II, Netherlands used the rubble as a base material and as an aggregate for concrete and asphalt. Besides, Germany between 1945 and 1955 used 123 million cubic meter of masonry aggregates in concrete applications. On the other hand, around the 1970s, in the Netherlands, the concern about quarry extractions created problems: many protests based in the preservation of the landscape and the fear of upsetting the biological balance took place. In 1978, the National Commission for Coordination of Soil Extraction Policies proposed measures to reduce the need for the extraction of minerals, such as importing natural materials and use alternative materials. In 1979, the Waste Materials Act was passed, with two clear objectives: achieving an efficient processing waste material, and reusing the waste material. Finally, in April 1998, the environmental legislation became more rigorous, preferring the reusable waste and forbidding the dumping. Currently there are several factors that lead to the use of waste materials as concrete aggregate or reused material in sub-bases to roads, etc. The main advantages of using Ceramic and demolition Waste concrete in the construction industry are of sustainable values and environmental issues. To overcome the issue of large volume of waste and increasing over time, manufacturing of sustainable concrete is one of the strategic action to be considered by the construction industry, oneway of achieving this is to introduce Ceramic and demolition Wastes into the production of concrete by replacing the fine aggregate from the concrete. Here I have used demolition waste produced by grinding the waste like old concrete blocks of concrete laboratory from S.H.I.A.T.S, Allahabad, U.P., India, along with the crushed and finely grinded waste ceramic tiles easily available in market as a partial replacement of fine aggregate in referral concrete for rigid pavement construction. The study has been carried out with the following objectives:

1. To study the effect of replacement of fine aggregate with demolition waste and Ceramic Waste by obtaining the compressive and flexural strength of PPC concrete to be used in rigid pavement.
2. To determine the optimum level of replacement of fine aggregate with demolition waste at particular dose of Ceramic Waste in rigid pavement.
3. To compare compressive and flexure strength of concrete made using demolition and Ceramic Waste with referral normal PCC concrete of rigid pavement.

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4. To find out the optimum percentage saving of fine aggregate by replacing it with demolition and ceramic waste for the rigid pavement.

## II. LITERATURE REVIEW

**Rushcecluzzafars and Khan (1984)** investigated the workability of recapitulated aggregate concrete made with coarse recapitulated aggregate sand to be somewhat improved as compared with the workability of corresponding original concrete. **karaa (1986)** had found that concrete produced with dry demolished aggregate loses its workability and sets faster than concrete produced with demolished concrete aggregate. **Kawamura anil Toni (1990)** confirmed that the fixture of recapitulated concrete is especially low when both line and coarse recapitulated aggregate are used. **ShulzandKaga (1991)** found that live minute of dry premixing the aggregate alone in concrete mixer actually improved the workability of the fresh concrete without improving the properties of hardened concrete. **Hanscn and Marga (1992)** concluded that on equal slump, the water requirement of recapitulated aggregate concrete made with both coarse and line dismantled waste was, 4% higher than that of controlled concretes made with natural sand and gravel. When concrete was produced with coarse recapitulated aggregate and natural sand, the increase in water demand was only 6%. **Ay and Unal (2000)** reported waste tiles shows Pozzolanic properties, chemical & physical properties of cement up to 35% of waste tile, after having the experimental investigation for usage of waste tiles as Pozzolana and replace with (OPC) cement in the range of 25%, 30%, 35%, & 40% by weight of concrete. **Mitsodeid. (2001)** compared the strength and economy of standard recapitulated concrete with partial replacement of cement and fine aggregates. The demolished concrete achieved up to 77% compressive strength, and above 90% for tensile arm flexural strength and a cost saving of 15%. These indicate the potential of C&D waste as valuable building materials on technical, environmental and commercial economic grounds. **Torgal et al. (2009)** has been found that concrete mixes possessing compressive strength of 30 M.Pa were prepared with 20% cement (OPC) replacement by ceramic powder. Although it has minor strength loss while increasing durability performance, but ceramic aggregates perform better. **Sukesh et al. (2012)** had found out experimentally that concrete with partial cement (OPC) replacement by ceramic powder has minor strength loss as the durability increases and eco-friendly cementitious materials are produced by using materials like ceramic waste etc. **Kamal et al. (2012)** shows that ceramic waste with natural coarse aggregate upto 40%, without affecting the mixes design strength. **Raval et al. (2013)** found that compressive strength of concrete for 7, 14, 28 days of curing achieved up to 30% replacement of cement with ceramic waste will be optimum without effecting the design concrete. **Hunchate et al. (2013)** explained the influence of water absorption on the strength of ceramic concrete which is declining, but this strength is more than the mean design strength, even after replacing natural coarse aggregate to 100%. **Hemant et al. (2015)** the maximum compressive strength obtained for the mix having 10% of crushed tiles and 20 % of tiles powder. The optimum percentage of coarse aggregate that can be replaceable by crushed tiles is 10%.

## III. MATERIALS AND METHODOLOGY

The details of this experimental investigations is for the measurement of the strength properties (compressive strength and flexural strength) percentages of demolition and ceramic waste as partial replacement of fine aggregates. This experimental investigation is conducted to get the strength of specimen (cube, beam ) made up with different percentage of ceramic waste and demolition waste to the respective strength of conventional concrete at the end of 7 and 28 days of moist curing. 30 cubes and 20 beams for a nominal mix have been cast in laboratory of M25 grade of concrete having proportion of materials was 1:1.5:3 and 1:1.25:2.5 with water cement ratio 0.46 is used as base for this research work keeping dose of super plasticizer was 0.3% by weight of cement. The coarse aggregate used in a combination of 50:50 individually sieved with IS sieve size 10 mm and 20 mm respectively. Used fine aggregate and ceramic sand confirm same zone according to IS 383 – 1970 in the study. The mixing is an extremely important aspect of concreting and it is important to follow the recommendation, Even a small deviation can have a large influence on the workability of the wet concrete and so the properties and appearance of final composite 50 control specimens (30 cubes + 20 beams) were being casted to determine the compressed strength and flexure strength at 7 and 28 days respectively. The specimens were mix using a nominal mix 1: 1.5:3 (where 3 is the proportion of 10mm and 20mm size aggregate) (15 cubes and 10 beams) cubes (100mmx100mmx100mm) each set of 3 and beams (500mmx100mmx100mm) set of 2 and with another mix 1:1.25:2.5 (where 2.5 is the proportion of 10mm and 20mm

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size aggregate)(15 cubes and 10 beams). In this project different specimens of concrete were prepared in order to consume waste ceramic tiles and demolition waste as a supplement or replacement of ingredients of concrete. The casting of specimens was prepared on mould box. All the mould box of different specimens was initially clean, tightened and oiled properly. There is no gap left where there is a possibility of leakage of slurry occurred. The coarse aggregate, fine aggregate and cement were weighted accurately. The concrete mix was prepared by hand mixing. Proper care was taken during weighting, mixing of ingredients and vibration of specimens for proper compaction. Pozzolana Portland Cement (PPC) was used in the casting of design mixture. Super plasticizer was added to required quantity of water in different batch of specimens of concrete. Fine aggregate was partially replaced with ceramic waste and demolition waste compositely. Different concrete specimens were prepared at different age of curing. Cube moulds of size  $100\text{mm}^3$  were used to prepare the concrete specimens for the determination of compressive strength of concrete. All the specimens were prepared accordance with Indian Standard Specifications IS: 516-1959. Beam mould of dimension  $10\text{cm}\times 10\text{cm}\times 15\text{cm}$  was used to prepared concrete specimens for determining the flexure strength of beam, according to the guidelines provided in IS 516: 1959. Concrete slump test must be performed for each batch of fresh concrete to know the Workability which is the measurement of consistency of a batch of concrete. The measured slump value as per IS: 1199 – 2004 guidelines. The apparatus used for doing slump test are Slump cone and tamping rod. Figure 3.4 shows a slump value of a mix. The bulk density measurement is used for determining the weight per cubic meter of freshly mixed concrete (density of concrete) from which the yield of concrete per cubic meter can be calculated. Bulk density of fresh concrete was measured as per IS 1199 - 2004 guidelines. The compressive strength testing machine may be of any reliable type, of sufficient capacity. The testing machine equipped with two steel bearing platens with hardened faces. Upper platens was fitted with a ball seating in the form of a portion of a sphere, the centre of which coincides with the central point of the face of the platen and other compression platen was plain rigid bearing block. Tests were conducted at recognized ages of the test specimens, the most usual being 7 and 28 days. The ages had been calculated from the time of the addition of water to the dry ingredient. At least three specimens, preferably from different batches, were made for testing at each selected age. The flexural strength testing machine may be of any reliable type of capacity used for testing. The bed of the testing machine was provided with two steel rollers of 38 mm diameter on which specimens were supported. These rollers were mounted at a distance of 40cm from centre to centre for 10cm specimens. The load was applied through two similar rollers whose centre to centre distance was 20cm. the load was applied axially without subjecting the specimens to any torsion stress or restrains. Test of specimens were performed at age of 7 and 28 days. The age of specimen had been calculated from the time of curing. Concrete product was usually being de-molded 12 to 18 hours after casting. In this process the mould was vibrated as the concrete mix was poured into it. Vibration of specimen has two functions. It enabled the mix to fill the mould completely. It release air trapped in the mix and allows compaction to take place. After mould filling removed any excess concrete which may interfere with de molding when the concrete has set Carry out final troweling when the concrete is still green, if is easier to do this to achieve a good trowel face than grinding when the concrete has set in the present study vibration table was used for vibration. It was considered best to use as little release agent as possible. Only a thin film is necessary. Concrete products will achieve a substantial proportion of their ultimate strength when the main cure is carried out for 7 and 28, in humidity of greater than 95% RH and with a minimum temperature of  $20^{\circ}\text{C}$ . A suitable post-curing regime will allow the remainder of the strength to be achieved.

## IV. RESULTS AND DISCUSSIONS

The observations made during the test of cubes are collected as compressive strength and flexure strength are presented in tabular form. Three specimens of cubes for compressive strength test and two specimens of the beams for flexure strength test as detail provided above having 0%, 20%cw+0%dw, 20%cw+10 %dw, 20%cw+15%dw and 20 % of each ceramic waste and demolition waste with which fine aggregate was being replaced for mix of 1:1.5:3 and 1:1.25:2.5 were casted and tested after 7 days and 28 days in order to have a comparative study. In all 30 cubes and 20 beams specimen were casted for the determination of compressive strength for all cubes their load carrying capacity with the corresponding delivious was measured. These observations are presented in tabular form as compressive strength values cubes up to 20% of fine aggregate replaced by demolition waste along with a constant dose of ceramic waste of 20% except specimen "O" "T" give strength close to the strength of plain concrete cubes and strength retention of more than required for mix 1:1.25:2.5 and 1:1.5:3 which can be recommended for construction of rigid pavement.

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Characteristics	Values Obtained	Standard Value
Initial Setting Time	24 min.	Min. 30 min.
Final Setting Time	345 min.	Max. 600 min.
Fineness (Specific Surface)	335	Min. 300 m <sup>2</sup> /Kg
Specific Gravity	2.9	3.5

Table1.Physical Properties of Cement

Days	Average Compressive Strength	Min. Value as per IS 1489 (Part 1) – 1991
3	22.5 N/mm <sup>2</sup>	16 N/mm <sup>2</sup>
27	34.0 N/mm <sup>2</sup>	22 N/mm <sup>2</sup>
28	45.0 N/mm <sup>2</sup>	33 N/mm <sup>2</sup>

Table 2.Compressive Strength of Cement

In this investigation Birla Gold (Fly Ash Based) cement was used for all concrete mixes. The cement was of uniform color (i.e. grey with a light greenish shade) and free from lumps. The initial and final setting time, specific gravity, fineness and compressive strength tests were conducted on cement. Testing of cement was done as per IS 4031(Part 5, 6)–2000. The various tests results are reported in table 1 and table 2respectively.

Characteristics	Value
Type	Crushed
Specific Gravity (10 mm)	2.4
Specific Gravity (20 mm)	2.4
Water Absorption (10 mm)	0.7%
Water Absorption (20 mm)	0.8%
Fineness Modulus (10 mm)	7.1
Fineness Modulus (20 mm)	7.4

Table 3.Physical Properties of Coarse Aggregate

Specific gravity, fineness modulus, water absorption testing of coarse aggregate both for 10 mm and 20 mm was done as per IS: 383-1970. The results of above physical properties tests conducted on coarse aggregate are given in Table 3.

IS Sieve Size	Weight Retained (kg)	Cumulative Weight Retained (kg)	Cumulative Percentage Retained	Cumulative Percentage Passing	IS 383-1970 Requirements
10	0	0	0	100	100
4.75	0.024	0.024	4.348	95.65	90-100
2.36	0.028	0.052	9.42	90.58	75-100
1.7	0.056	0.108	19.57	80.43	
1.18	0.076	0.184	33.33	66.67	55-90
0.6	0.094	0.278	50.36	49.64	35-59
0.3	0.098	0.376	68.12	31.88	8-30
Pan	0.176	0.552	100	0	

Table 4.Sieve Analysis of 10 mm Aggregate

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IS Sieve Size	Weight Retained (kg)	Cumulative Weight Retained (kg)	Cumulative Percentage Retained	Cumulative Percentage Passing	IS 383-1970 Requirements
20	0.038	0.038	0.76	99.24	85-100
12.5	4.074	4.112	82.24	17.76	
10	0.18	4.292	85.84	14.16	0-20
4.75	0.694	4.986	99.72	0.28	0-5
2.36	0.014	5	100	0	

Table 5.Sieve Analysis of 20 mm Aggregate

Sieve analysis of coarse aggregate both for 10 mm and 20 mm was done as per IS: 383-1970. The results of above physical properties tests conducted on coarse aggregate are given in Table 4 and table 5.

IS Sieve Size(mm)	Weight Retained (kg)	Cumulative Weight Retained (kg)	Cumulative Percentage Retained	Cumulative Percentage Passing	IS 383-1970 Requirements
25	0	0	0	100	100
20	0.023	0.023	0.46	99.54	95-100
12.5	2.500	2.523	50.46	49.54	
10	0.250	2.773	55.46	44.54	25-55
4.75	2.227	5	100	0	0-10

Table 6.Sieve Analysis of Combined Coarse Aggregate

Locally available coarse aggregate with fraction of 20 mm and 10 mm were used where both the fraction completely passed through 20 mm sieve and 10 mm sieve individually. In mix the ratio of these aggregates was 50:50 respectively. Aggregate were washed to remove dust and dirt. Testing of coarse aggregate was done as per IS: 383-1970. The results of various tests conducted on coarse aggregate are given in Table 3, Table 4, Table 5 and Table 6.

Characteristics	Value
Type	Uncrushed (natural)
Specific Gravity	2.1
Free Surface Moisture	1%
Fineness modulus	2.9
Grading Zone	II

Table 7.Physical Properties of Fine Aggregate

IS Sieve Size(mm)	Weight Retained (kg)	Cumulative Weight Retained (kg)	Cumulative Percentage Retained	Cumulative Percentage Passing	IS 383-1970 Requirements
10	0	0	0	100	100
4.75	0.025	0.025	5.0	95.0	90-100
2.36	0.029	0.054	10.8	89.2	75-100
1.7	0.036	0.009	18.0	82.0	
1.18	0.049	0.139	27.8	72.2	55-90
600 $\square$	0.085	0.224	44.8	55.2	35-59
300 $\square$	0.216	0.440	88.0	12.0	8-30
150 $\square$	0.060	0.500	100	0	0-10

Table 8.Sieve Analysis of Fine Aggregate

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River sand available in Allahabad confirming to IS 383-1970 zone II, is used in the study. It was completely passed by 4.75 mm IS sieve to remove any particles greater than 4.75 mm. Physical properties and sieve analysis results of fine aggregates are listed in Table 7 and Table 8 respectively

Si no	Specimen name(cubes)	Size(mm) (sides)(L*B*H)	Proportion	Water content	%replacement of ceramic waste	%replacement of demolition waste
1	O	100*100*100	1:1.5:3	0.46	0	0
2	A	100*100*100	1:1.5:3	0.46	20	0
3	B	100*100*100	1:1.5:3	0.46	20	10
4	C	100*100*100	1:1.5:3	0.46	20	15
5	D	100*100*100	1:1.5:3	0.46	20	20
6	I	100*100*100	1:1.25:2.5	0.46	0	0
7	J	100*100*100	1:1.25:2.5	0.46	20	0
8	K	100*100*100	1:1.25:2.5	0.46	20	10
9	L	100*100*100	1:1.25:2.5	0.46	20	15
10	M	100*100*100	1:1.25:2.5	0.46	20	20

Table 9.specification of cube specimens for compressive strength test

Si no	Specimen name(beams)	Size(mm) (sides) (L*B*H)	Proportion	Water content	%replacement of ceramic waste	%replacement of demolition waste
1	O	500*100*100	1:1.5:3	0.46	0	0
2	A	500*100*100	1:1.5:3	0.46	20	0
3	B	500*100*100	1:1.5:3	0.46	20	10
4	C	500*100*100	1:1.5:3	0.46	20	15
5	D	500*100*100	1:1.5:3	0.46	20	20
6	I	500*100*100	1:1.25:2.5	0.46	0	0
7	J	500*100*100	1:1.25:2.5	0.46	20	0
8	K	500*100*100	1:1.25:2.5	0.46	20	10
9	L	500*100*100	1:1.25:2.5	0.46	20	15
10	M	500*100*100	1:1.25:2.5	0.46	20	20

Table 10.specification of beam specimens for flexural strength test

Specimen are casted to determine the compressive strength and flexure strength at 7 and 28 days were mixed with different levels of replacement of fine aggregate with ceramic waste whose dose is kept constant and with varying dosage of demolition waste except for specimen O and I where no replacement is done. Layout of experimental design is given in the table 9 and table 10.

Specimen Name	Size (mm) Sides	Flexural strength after 28 days N/mm <sup>2</sup>	Flexural strength after 7 days N/mm <sup>2</sup>
O	100*100*500	8.2	4.8
A	100*100*500	7.6	4.9
B	100*100*500	6.8	4.6
C	100*100*500	8.0	5.7
D	100*100*500	7.4	4.8

Table 11.flexural strength of beam of proportion 1:1.5:3

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Specimen Name	Size (mm) Sides	Flexural strength after 28 days N/mm <sup>2</sup>	Flexural strength after 7 days N/mm <sup>2</sup>
I	100*100*500	7.7	3.8
J	100*100*500	7.6	3.9
K	100*100*500	6.6	4.6
L	100*100*500	7.6	4.2
M	100*100*500	6.9	4.7

Table 12. flexural strength of beam of proportion 1:1.25:2.5

The flexural strength of specimens, expressed as modulus of rupture  $f_b$ ;  $f_b = \frac{PLa}{bd^2}$   $> 13.33 \text{ cm}$ ,  $f_b = \frac{3Pa}{bd^2}$   $= (11 \text{ to } 13.33)$  Where, a = distance between the line of fracture and near support, measured on the centre line of tensile side of specimens in cm, b = measured width in cm of specimens, d = measured depth in cm of specimens at the point of failure, L = length in cm of span on which the specimens was supported, P = maximum load in kg applied to the specimens. The average flexure strength was calculated as stated above and presented in a tabular form in table no 11 and 12 for the proportion 1:1.5:3 and 1:1.25:2.5 respectively. For graphical representation of observation of table no 11 and 12 refer to figure no. 1 and 2.

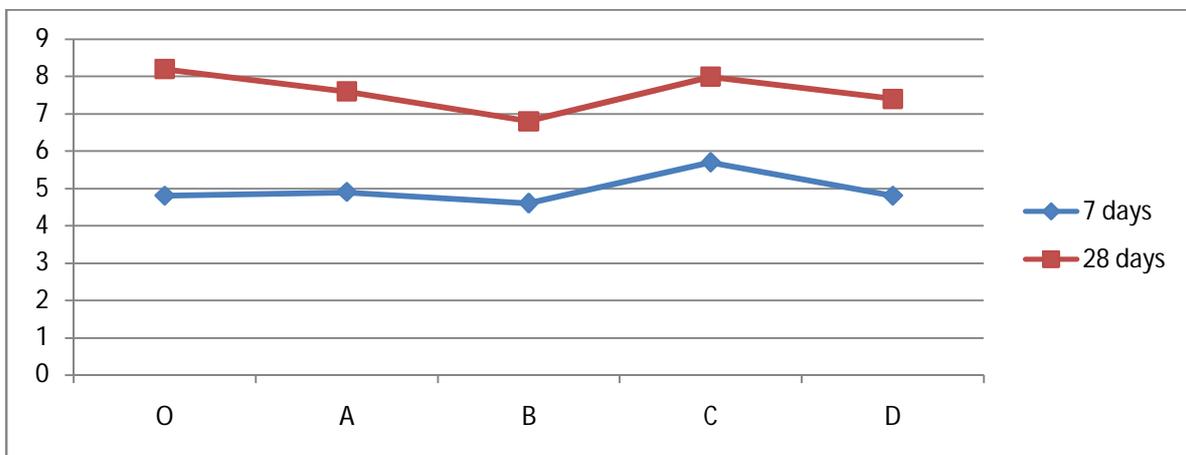


Fig1. flexural strength comparison of beam specimen of proportion 1:1.5:3

From the above chart it can be seen that for the specimen with replacement of fine aggregate with 20% ceramic waste and 10% demolition waste showing the lowest strength and if again the demolition waste level is increased up to 15% with same dose of ceramic waste then strength is again seen to be increasing and is above at 7 days and nearly equal to that of 28 days strength report to that of normal concrete mix for the proportion 1:1.5:3. It can also be seen that at a replacement level of 20% of both the ceramic and demolition waste the strength is again decreasing but nearly equal to that of nominal reference mix.

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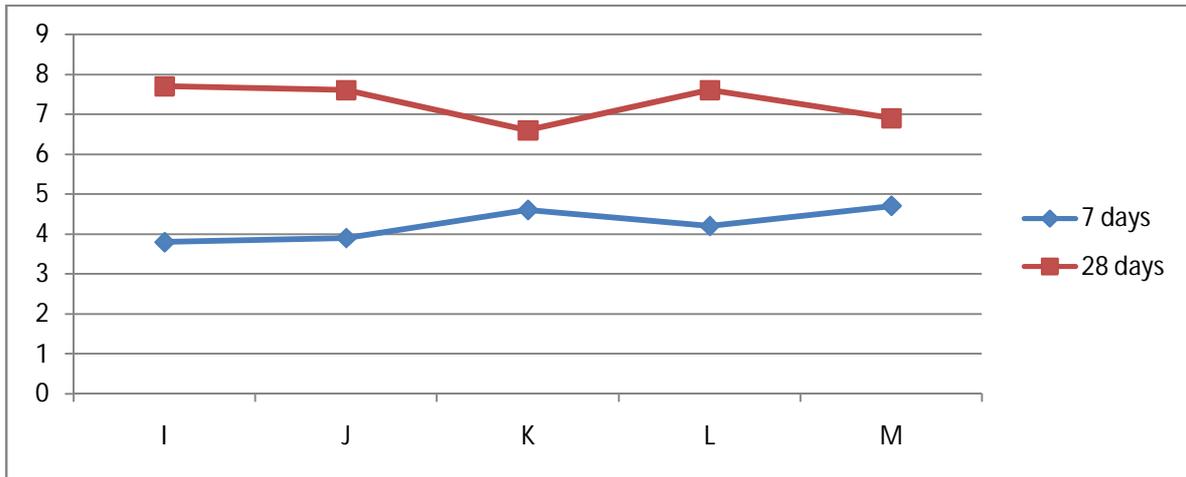


Fig2.flexural strength comparison of beam specimen of proportion 1:1.25:2.5

From the above chart it can be seen that for the specimen with replacement of fine aggregate with 20% ceramic waste and 10% demolition waste showing the highest flexure strength at an age of 7 days but finally the lowest strength at an age of 28 days and if again the demolition waste level is increased up to 15% with same dose of ceramic waste than strength is again seen to be decreasing for 7 days strength result but increasing for 28 days strength result above the strength of normal concrete at an age of 7 days and nearly equal to that of 28 days strength to that of normal concrete mix for the proportion 1:1.25:2.5. It can also be seen that at a replacement level of 20% of both the ceramic and demolition waste the strength is again increasing at an age of 7 days and is more than that of normal concrete but finally at an age of 28 days the strength is decreasing but nearly equal to that of nominal referral mix.

Specimen Name	Size (mm) Sides	Compressive strength after 28 days N/mm <sup>2</sup>	Compressive strength after 7 days N/mm <sup>2</sup>
O	100*100*100	28.50	20.00
A	100*100*100	34.66	21.00
B	100*100*100	30.00	20.80
C	100*100*100	34.33	17.76
D	100*100*100	32.50	22.50

Table 13.compressive strength of cubes of proportion 1:1.5:3

Specimen Name	Size (mm) Sides	Compressive strength after 28 days N/mm <sup>2</sup>	Compressive strength after 7 days N/mm <sup>2</sup>
I	100*100*100	32.66	15.76
J	100*100*100	34.00	15.50
K	100*100*100	35.50	19.33
L	100*100*100	35.66	17.50
M	100*100*100	32.00	17.67

Table 14.compressive strength of cubes of proportion 1:1.5:3

The analogue compression testing machine conforms to IS 14858 – 2000 of capacity 2000kN was used in this investigation. Cube moulds of size 100mm<sup>3</sup> were used to prepare the concrete specimens for the determination of compressive strength of concrete. All the specimens were prepared accordance with Indian Standard Specifications IS: 516-1959. The results found as average compressive strength were presented in a tabular form in table no 13 and 14 for

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1:1.5:3 and 1:1.25:2.5 respectively. For graphical representation of observation of table no 13 and 14 refer to figure no. 3 and 4.

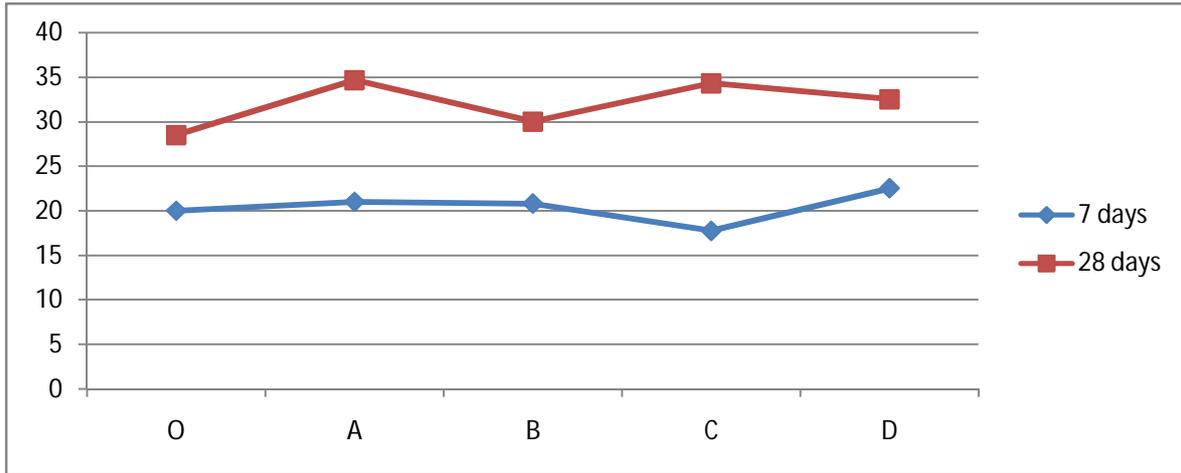


Fig3.compressive strength comparison of cube specimen of proportion 1:1.5:3

From the above chart it can be seen that for the specimen with replacement of fine aggregate with 20% ceramic waste and 0% demolition waste showing the highest compressive strength at an age of 7 days and 28 days and if again the demolition waste level is increased up to 15% with same dose of ceramic waste than strength is again seen to be decreasing for strength at an age of 7 days and increasing for 28 days strength result but nearly equal to that of the strength of normal concrete at an age of 7 days and above than that of 28 days strength to that of normal concrete mix for the proportion 1:1.5:3. It can also be seen that at a replacement level of 20% of both the ceramic and demolition waste the strength is again increasing at an age of 7 days and decreasing for that of 28 days but is more than that of normal referral concrete mix.

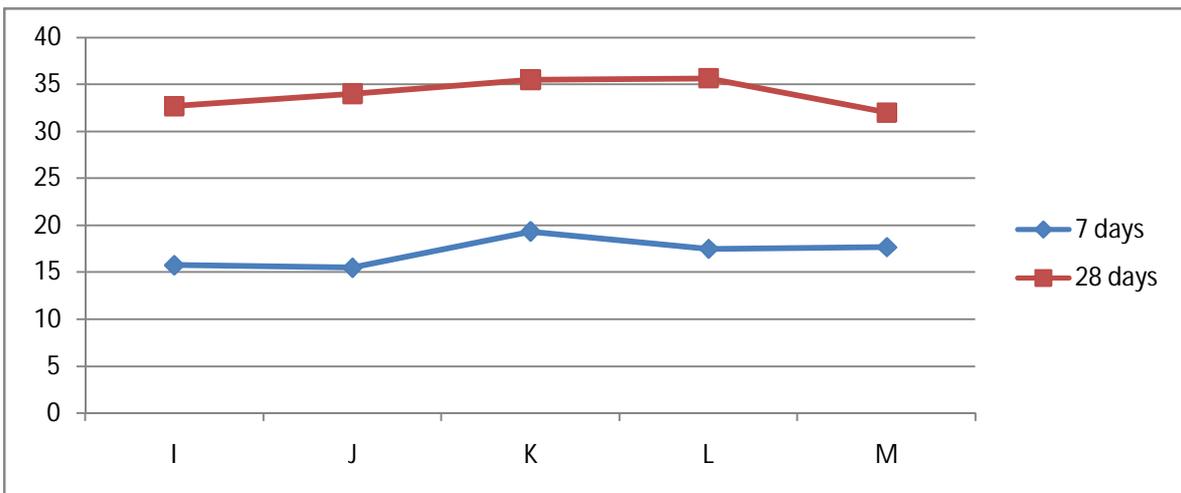


Fig4.compressive strength comparison of cube specimen of proportion 1:1.25:2.5.

From the above chart it can be seen that for the specimen with replacement of fine aggregate with 20% ceramic waste and 10% demolition waste showing the highest compressive strength at an age of 7 days and if again the demolition waste level is increased up to 15% with same dose of ceramic waste than strength is again seen to be

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decreasing for strength at an age of 7 days and increasing for that of 28 days strength result but above the strength at an age of 7 days and 28 days strength to that of normal concrete mix for the proportion 1:1.25:2.5. It can also be seen that at a replacement level of 20% of both the ceramic and demolition waste the strength is again increasing at an age of 7 days and decreasing for 28 days but is nearly equal to that of normal referral concrete mix.

## V. CONCLUSION

From the above study the following conclusion may be drawn:

1. By using ceramic and demolition waste 40 % natural fine aggregate can be saved while making rigid pavement
2. Up to 20 % demolition waste and 20 % ceramic waste compressive strength is more than that of referral concrete.
3. Flexural strength is more than that of referral concrete at all most all the replacement levels
4. Ceramic and demolition waste up to 20% each all together can be used as partial replacement of fine aggregate.

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