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EXPERIMENTAL INVESTIGATION OF HIGH PERFORMANCE CONCRETE BY PARTIAL REPLACEMENT OF FINE AGGREGATE BY CONSTRUCTION DEMOLITION WASTE

A.NaveenArasu[1], K. Manickaraj[2], P.Karthigaiselvi[3]

naveenanbu07@gmail.com,

[1&3]Assistant Professor, Dept. of Civil Engineering, CMS college of Engineering & Technology, Coimbatore, Tamil Nadu,

[2]Professor, Dept. of Civil Engineering, CMS college of Engineering & Technology, Coimbatore, Tamil Nadu,

Abstract

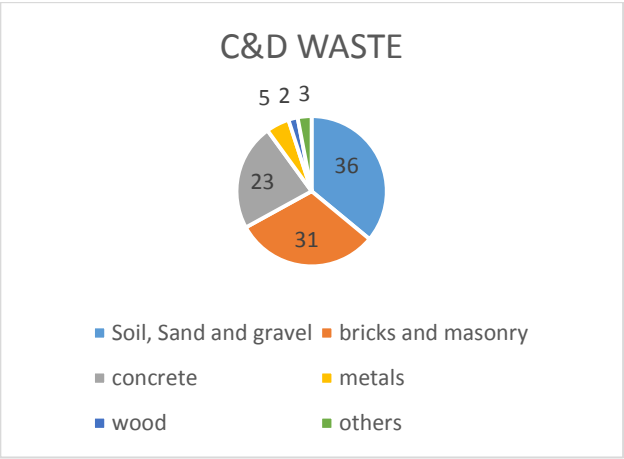
Rapid urbanisation in the developing globe necessitates the change of construction materials due to increased demand for naturally accessible construction resources. Because natural fine aggregates are becoming scarce, construction demolition debris is being used to replace them. Construction, renovation, repair, and demolition of houses, big building structures, roads, bridges, dams, and other buildings create demolition trash. Only 5% of C & D debris is recycled or utilised.

Various tests have been conducted to increase the compressive strength, flexural strength, and tensile strength of concrete by partially replacing natural fine aggregate with recycled fine aggregate. The test is carried out using various percentages of crushed C & D waste fine aggregate substitution for natural fine aggregates, such as 10%, 20%, 30%, 40%, and 50%. The compressive strength, split tensile test, and flexural test results of recycled fine aggregate in concrete were compared to those of conventional concrete. Compressive strength and tensile strength of concrete with recycling natural fine aggregates with 20% replacement of crushed C & D waste fine aggregates were observed in several experimental tests. Different tests have enhanced the strength by roughly 5% in compressive strength, 6% in flexural strength, and 8% in tensile strength. With replacement crushed C & D waste of 30%, 40%, and 50%, floor corner admixtures are used to strengthen the compressive, tensile, and flexural strength of concrete. Different tests have raised the strength to around 5.5 percent in compressive strength, 6.25 percent in flexural strength, and 9 percent in tensile strength.

Introduction

Construction and demolition waste (C&D waste) is generated from construction, renovation, repair and demolition of houses, large building structures, roads, bridges, dams. C&D waste is made up of

- Concrete
- Soil
- Steel, wood and plastic
- Other materials – bricks and mortar



The importance of C&D waste management is not lost among the stakeholders especially in large cities, where impacts have already been felt. But still effective management of C&D waste is hampered by several challenges and implementation is far from ideal.

The improperly managed waste heaps impacts the system and the environment in multiple aspects which could broadly be classified into the following aspects

SOCIAL

- Huge heaps of C&D waste on footpaths, carriageways, alleys and all is a common scene in Indian cities turning the surrounding un aesthetic.
- The C & D debris usually could not be removed by Normal Street sweeping or household waste collection staffs as they usually do not carry the equipment neither enough capacity in the collection vehicle no enough manpower.
- Usually the polluters tend to dump other municipal solid waste on the heap making it a mix of waste further creating an unsanitary situation.
- Clearing drain silts is a major challenging activity for local governing bodies and major percentage is consisted of by C&D.

- The C & D waste is also stealthily dumped in open drains, water channels, and even riverbeds. The debris clog the drains and create water logging. Reports of water logging of drains turning to source for spread of epidemics is common in India
- The C&D waste also consists of several kinds of materials which include sharps, broken glasses, boulders, broken wooden logs, rusted metal, broken ceramics etc which create a hazardous environment when dumped or unfenced open places.

ENVIRONMENTAL

- C&D waste is also a source of environment pollution: The C&D debris over course of time forms fine dust creating air pollution and reducing visibility.
- The leach ate and fine chemical particles degrade the soil leading to land pollution and in addition materials like paint, oil and asbestos sheets are common components of C&D waste which are bio hazards in nature having potential to endanger health of workers handling the waste, civilians and any living organism.
- Formation of slit deposit when dumped in wet lands and water bodies damaging the water ecosystem.

ECONOMIC

- C&D waste usually gets mixed up with the other municipal solid waste also during the process of transfer or at the collection site.
- C&D waste is very difficult to segregate. Separate labour has to be employed for manual segregation or it has to be performed using earth moving machine, in addition the processing efficiency also get reduced due to the presence of other waste mixed with C&D waste which becomes more complicated.
- The huge mass of C&D waste results in occupying a large volume of landfills and dump yards resulting in governing bodies to find alternative space and creation of more landfills, again leading to economic inefficiency in system.

RESOURCESHORTAGE

India is witnessing a boom in construction industry due to the urbanization which leads to over exploitation of primary resource to match the demands. For instance almost 100% in case of cement and bricks, 40 – 60% of steel, 85% of paint and 70% glass produced in India goes into construction sector. The anticipated growth of sector in the near future exert added pressure on limited stocks of resource especially sand, soil, stone and lime stone which have been identified as most critical resources. Therefore use of secondary materials need to be promoted to supplement the use of primary materials and recycled C&D waste is one of the best available option available as secondary raw material.

2. Literature review

S.Jayakumar, S.Nivedita, T.Vedasangavai [March – 2016]: This experimental study highlights the demand of natural fine aggregate river sand. In order to overcome the demand of natural fine aggregate the brick bat debris is used for building construction. The debris were crushed and graded as per the IS code 383 for fine aggregate. The crushed debris were partial replaced with natural fine aggregate. The compressive strength for the different concrete mix of concrete debris with natural fine aggregate were done and result is calculated. From various test it is identified that the 40% of cement mortar debris with natural fine aggregate gives the good compressive strength.

Rachit Sharma[2017]: From this paper gives us the good results on construction demolition waste or glass waste with or without using super plasticizer and fiber. The compressive strength of concrete on 28th day by replacement of fine aggregate with construction demolition waste attains a good result. When fine aggregate is replaced with construction demolition waste to the extent of 30%, an increase in compressive strength is observed. The replacement of fine aggregate with glass waste including the use of super plasticizer and fiber tends to increase compressive strength. However, if construction and demolition waste aggregates and waste glass replacing fine aggregate including super plasticizer and fiber are used, the compressive strength achieved is less. The construction & demolition waste and/or glass waste can be used in concrete yielding improved compressive strength, there by solving the problem of disposal as well as preserving the environment.

JaanusriManoharan, Mrs. K. Shanthi [Oct-Dec 2016]: This paper gives the usage of C&D waste in place of fine aggregate as partial replacement in concrete. By various percentage of partial replacement of fine aggregate

the concrete is done. Then the compressive and tensile strength of the concrete is tested on 7th, 14th& 28th days. From the test result, it is obtained that the partial replacement of fine aggregate with 10%, 20% & 30% of construction demolition waste the values of compressive and tensile strength is increased effectively. But on 35% & above the partial replacement of fine aggregate with construction demolition waste the compressive and tensile strength of the concrete is reduced. So from this experimental investigation, it is obtained that the 30% of partial replacement of fine aggregate with construction demolition waste the values of compressive strength and tensile strength is increased.

Dr.suji.D, Narayanan.A.M,KarticKumar.M, Perarasan. M [June – 2016]: This experimental study highlights about the scarcity of natural good quality fine aggregate. In order to reduce the demand the fine aggregate is partially replaced with quarry dust and saw dust. The fine aggregate is partially replaced with quarry dust with various percentage of about 10%, 20%, 30% & 40% and saw dust in the percentage of about 5%, 10%, 15% & 20%. From this various partial replacement of fine aggregate, the result comprise that the 30% of quarry dust and 15% of saw dust replaced for fine aggregate, the compressive strength of 36.26N/mm^2 for 28 days for M30 grade of concrete is achieved and split tensile strength of 3.8N/mm^2 for 28 days is achieved. By increasing the percentage of saw dust, it is found that the cost for the concrete mixture is reduced and the weight is reduced by to 20%.

Tomas U. GanironJr[2015] : This experimental study aims the use of crushed concrete waste as a partial replacement for fine aggregate. In this the mortar mixture of concrete debris is compared with the conventional mortar mix. From this it is determined that the concrete waste mortar mixture is compared with conventional mortar of same proportion and various test are done and result is noted.

A.NaveenArasu, S.Vivek, J. Robinson, T. ThilakRanjith[2017]: This experimental study highlights about the usage of waste foundry sand as a partial replacement for fine aggregate. The waste foundry sand is used as a partial replacement of fine aggregate in the ratio of about 5%, 10% & 15% in various mix proportion and various test is done and result is determined. From these result it is identified that the compressive strength of the concrete is increased to a great extent for the partial replacement of fine aggregate with waste foundry ratio at a percentage of about 20%.

Hemalatha B.R, Nagendra Prasad, B.V.VenkataSubramanya [2008]: This paper highlights about the usefulness of the construction and demolition waste. Due to reuse of C&D waste, the land gets polluted. In order to overcome this problem the construction and demolition waste can be recycled and used in the field of the concrete technology.

SaswatHota, Vikas Srivastava [2016]: This paper highlights about the usage of ceramic and demolition waste in rigid pavement the ceramic and demolition waste 40% natural aggregate can be saved. By using 20% of ceramic waste and 20% of demolition waste as partial replacement of fine aggregate, the compressive strength and the flexural strength is more than that of the convential concrete.

Sylvester O. Osuji, DafeIkogho [2017]: This paper highlights about the usage of naphthalene based chemical admixture for M30 grade of concrete and above. From this the properties of admixture and usage of admixture is identified.

a) Construction & Demolition Waste

Construction & Demolition waste is a waste debris from destruction of a construction. Construction industry in India generates about 10-12 million Tons of waste annually. While Retrievable items like bricks, wood, metal, titles are recycled in India. Concrete and masonry waste about 50% of total waste are not recycled. In order to overcome this problem, the Construction &demolition waste is recycled and partially used as a fine aggregate in concrete.

Fig.1. Construction & Demolition waste

Table1. Physical properties of C&D waste

Property	Value
Specific gravity	2.475
Water absorption	1.01%
Bulk density	1440 kg/m^3
Voids ratio	0.60
Porosity	36.20%

SOURCE: C & D waste, Coimbatore

b) Cement

Ordinary Portland Cement (53 grade) conforming to IS: 12269 -1987 and specific gravity of cement was determined as 3.15 was used for casting all the specimens. Fineness of cement test was conducted by sieve analysis (using 90 µ sieve), specific gravity using Le-chatlier's apparatus, initial setting time and final setting time using vicat apparatus.

Table 2. Properties of cement

Property of Cement	Values
Fineness Of Cement	8%
Grade Of Cement	53
Specific Gravity	3.15
Initial Setting time	30 minutes
Final Setting Time	600 minutes

c) Fine aggregate

Fine aggregate is a mixture of small particles of sand & grains which passes through IS 4.75 mm sieve and as per the recommendation of IS: 383-1970 was used for all the specimens. Specific gravity test was conducted on fine aggregate using pycnometer, fineness modulus by sieve analysis.

Table 3. Properties of Fine Aggregate

Properties	Values
Specific Gravity	2.74
Fineness Modulus	2.805

c) Coarse aggregate

Coarse aggregate means which is breaked from rocks using explosives & crushed into pieces using machines. Specific gravity test of coarse aggregate was conducted using pycnometer and coarse aggregate passing through 20 mm sieve and retained on 12.5 mm sieve was taken and as given in IS: 383 - 1970 is used for all the specimens.

Table 4. Properties of Coarse Aggregate

Properties	Values
Size Of Aggregates	20 mm
Specific Gravity	2.80
Fineness Modulus	7.17

d) Water

The potable water is used for casting and curing of specimen as per IS 456:2000.

Table 5. pH Value Test

WATER	pH VALUE
Sample 1	7
Sample 2	7
Sample 3	7

9. Mixture Preparation for Cube Casting

Table 6. Mix Proportion (M_{50})

Unit of Batch	Water (Litres)	Cement (Kg)	F.A (Kg)	C.A (Kg)	Admixture(Litres)
Cubic meter content	191	547	726.1	1008	10.94
Ratio of ingredients	0.5	1	1.32	1.84	3.0

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Table 7. Mix Proportions of Concrete

Type	C&D Waste		
C&D waste (%)	10	20	30
Cement (kg/m^3)	563.31	563.31	563.31
FA (kg/m^3)	656.75	571.26	510.807
CA (kg/m^3)	991.32	991.32	991.32
Water (kg/m^3)	22.05	197.16	193.26
Admixture ($kg/m^{3)}$	0.0075	0.005	0.003
C&D waste(kg/m^3)	62.81	129.04	193.116

4. Experimental methodology

i) Casting of Cubes

Various cubes were made (Fig. 3.9.2) using concrete mixture without using C & D waste and concrete mixture with using C & D waste as partial replacement of fine aggregate with different range of percentage such as (10%, 20% & 30%).

Fig. 2. Casting of Concrete Cubes (M20)

ii) Curing of Concrete Cubes and Beams

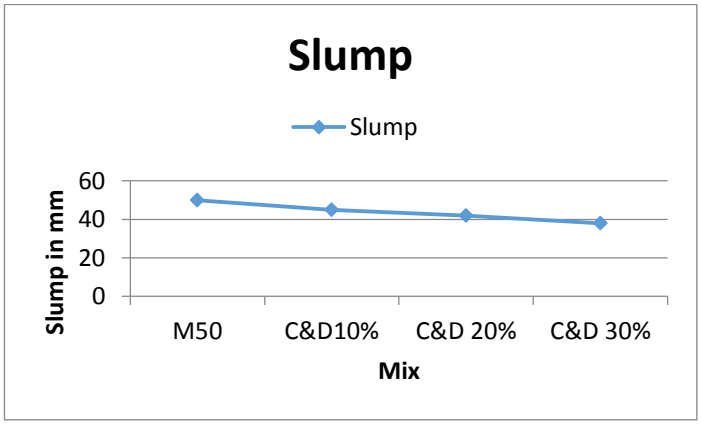
After casting of concrete, all the mould specimens were stored at room temperature in the casting room. They were de-moulded after 24 hours, and were put into a water-curing tank for 28 days at room temperature.

5. Test on fresh concrete

i) Slump Cone test results

Table 8. Workability of all mixtures

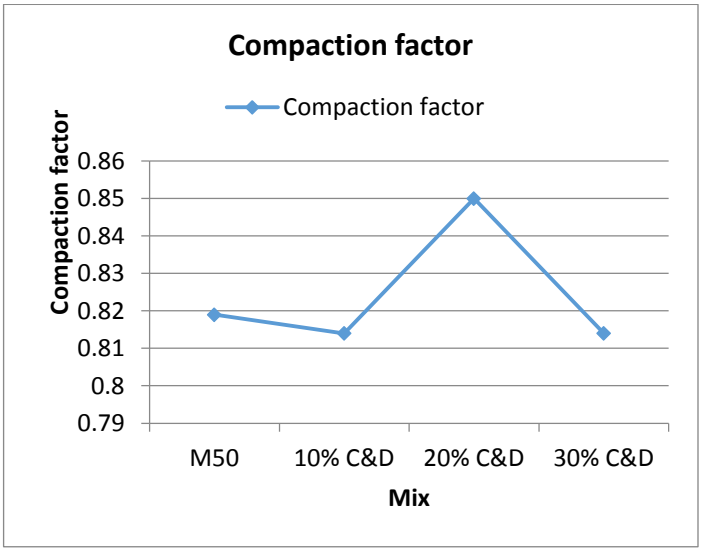
Control Mix	M50	C&D10 %	C&D 20%	C&D 30%
Value	50	45	42	38

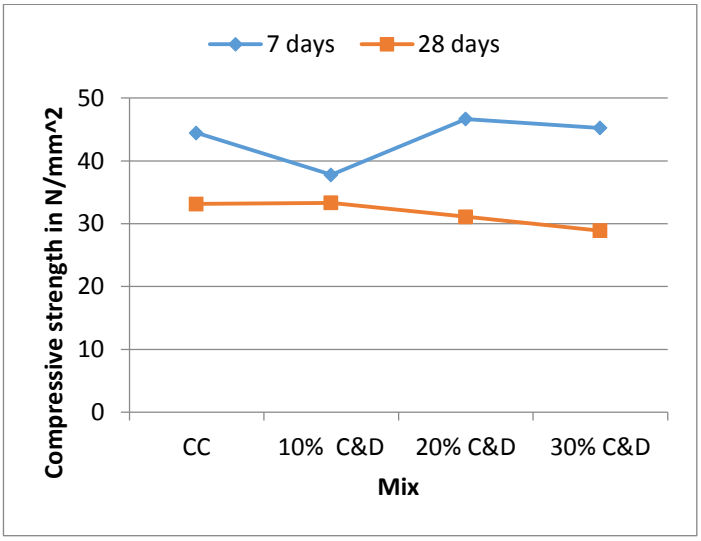


ii) Compaction factor test results

Table 9. Compaction Factor Test

Concrete mix	Partially compacted concrete (kg)	Fully compacted concrete (kg)	Compaction factor
M50	10.28	12.54	0.819
10% C&D	12.40	15.2	0.814
20% C&D	12.75	14.92	0.85
30% C&D	12.56	15.52	0.814





12. Tests on Harden Concrete

i) Compressive strength test

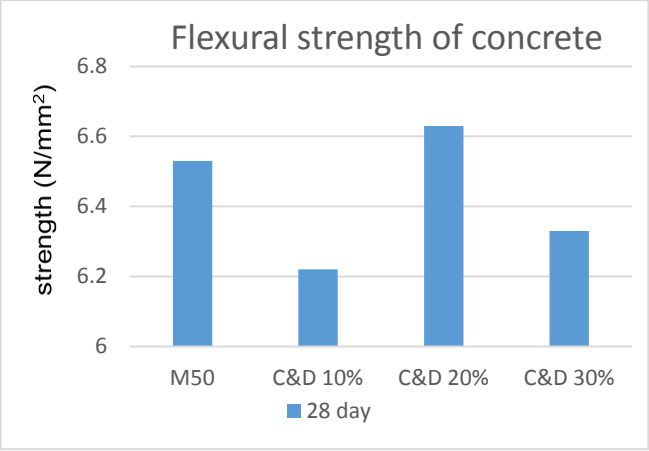
Table 10. Compressive Strength Test in C&D Waste

Concrete	Description	7 days	28 days
Conventional concrete	Compression strength (N/mm^2)	44.44	33.14
10% replacement by C&D	Compression strength (N/mm^2)	37.77	33.33
20% replacement by C&D	Compression strength (N/mm^2)	46.66	31.11
30% replacement by C&D	Compression strength (N/mm^2)	45.23	28.88

ii) Structural flexural behaviour of C&D beams

Table11. Flexural Strength of Normal Concrete and C&D Concrete – 28 days

S.NO	NAME OF THE SPECIMEN	% REPLACEMENT C&D	FLEXURAL STRENGTH (N/mm^2)
			28Days
1.	M1	0%	3.73
2.	M2	10%	3.86
3.	M3	20%	4.08
4.	M4	30%	3.81



6. CONCLUSIONS

The present work investigated the physical and chemical properties of construction demolition waste. Concrete properties (compressive strength, water absorption and porosity) were analysed for untreated C&D waste and reclaimed C&D waste as partial replacement of sand (10%, 20% and30%). On the basis of the results from the present study, following conclusions are drawn.

Based on the test carried out on the five mixtures the following conclusion has been made:

- The fineness and high water absorption properties of the C&D waste and Reclamation of C &D waste affects the workability of the concrete, and the workability of the concrete gets reduced by the increase in the C&D waste substitution rate.
- After some age the strength properties of the concrete mixtures containing C&D waste up to 20% was relatively close to the strength value of the CC.
- The concrete mixtures of C&D waste and Reclamation of C&D waste 20% and 30% showed a decrease in compressive strength of only 2.03% and 5.7%, respectively, at the age of 28 days when compared to the CC.
- Water absorption, voids, porosity decreases with addition of C&D waste compared to CC.
- From the results obtained it is suggested that C&D waste with a replacement rate up to 30% can be used effectively as a fine aggregate in good concrete production without affecting the concrete standards.

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