RECYCLING OF DEMOLITION WASTE IN CONCRETE CONSTRUCTION

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INTRODUCTION

Concrete is the most widely used material of construction all over the world. A huge quantity of concrete is consumed by global construction industry. In India, the traditional concrete is mostly prepared by using natural sand obtained from the riverbeds as fine aggregate. India is a developing country where the growth rate is increasing and side by side waste material is also increased so there is a need of the management of waste material in India. Due to the increase in population, IT sector, new infrastructure projects and industrialization, the construction industry has shown very fast growth. Builders face the problem of financial difficulty due to the excessively material wastage in construction projects.

Globally, cities generate about 1.3 billion tonne of solid waste per year. This volume is expected to increase about to 2.2 billion tonneby report by the World Bank. Building materials account for about half of all materials used and about half the solid waste generated worldwide. They have an environmental impact at every step of the building process-extraction of raw materials, processing, manufacturing, transportation, construction and disposal at end of building's useful life.

The characteristics of demolition waste may vary depending on the types of structures demolished and demolition technique used. It has been established that materials from demolished buildings are being reused for new construction works as renovation projects, especially by low-income communities in developing countries.

METHODOLOGY

General

Obtaining construction debris from a demolition site, screening, washing with water and then hammering it to reduce it to the required size

Obtaining natural aggregate of similar size.

Conducting following tests on the natural aggregates
Sieve analysis
Specific gravity test and water absorption test
Slump cone test

Casting cubes made up of
1. Completely normal cement concrete
2. Replacement of 20% coarse aggregate by demolished M20 grade concrete
3. Replacement of 30% coarse aggregate by demolished M20 grade concrete
4. Replacement of 40% coarse aggregate by demolished M20 grade concrete

and conducting slump cone test and compressive strength test on these cubes at duration 7 days and 28 days. Comparing the results of both sets of cubes. Based on results obtained decide the admixture to be used to enhance the properties of concrete.

Laboratory & testing work

The design characteristic strength of concrete depends upon properties of aggregates, type of cement, type of exposure conditions and method of compaction. Concrete may be used for high level engineering works, for that we need to examine properties of ingredients of concrete by performing various tests on them. Various suggestions will be made in the design to improve the performance of concrete.

To achieve planned objectives various experiments were carried out in detail with proper proportions and specified materials to be held effectively replace concrete ingredient with obtained recycled material. Test results are used to identify suitable replacement with specimen characterization of concrete ingredients. Planned objectives suggests the use of concrete with recycled aggregate's application in various construction activities.

All experiments conducted with IS specifications and with technical guidance from respective staff and faculties.

Material characterization

1. Cement: Cement used was free from air set lumps and it was of grade OPC 43 grades manufactured by ACC.
2. Aggregate: Aggregates and sand available were used as coarse aggregates and fine aggregates respectively. Sand should have a maximum size of 4.75 mm. and aggregates should have maximum size of 20 mm.
3. Water: Water used was fresh potable water.

Material characterization for Aggregate

- The properties of aggregates used in conventional concrete are examined with various tests conducted on it.
- The Fine and Coarse aggregates used in conventional concrete should be confirming to IS 383 (1970).
- According to standards for aggregates to be used in various construction processes the tests conducted on Natural Aggregates with reference to IS 2386(part 3)-1963 are listed below:

1. Specific Gravity and Water Absorption test
2. Compressive strength test

Specific Gravity and Water Absorption test

The laboratory work was planned and Specific Gravity and Water Absorption tests were performed confirming to IS 2386 (part 3):1963 and following procedure was adopted.

1. The 2 kg of coarse aggregates are washed and air dried to remove dust and dirt.
2. Air dried aggregates are placed in basket and immersed in distilled water at a temperature between 230C-320C with a cover of at least 5 cm of water above the top of the basket.
3. The basket and aggregate are kept immersed in water completely for a period of 24 hours.
4. The basket and sample are then weighed while suspended in water and noted as W1.
5. The basket and aggregate are then removed from water and allowed to drain for few minutes, after which aggregates are gently emptied from basket on the dry cloth and the empty basket is then returned to tank of water and weighed as W2.
6. The aggregates are surface dried and then moved to second dry cloth spread in single layer and allowed to dry for 10 minutes and weighed as W3.
7. The aggregates are placed in shallow tray and kept in an oven maintained at temperature of 1100C for 24 hours. They are then removed from the oven, cooled in an air-tight container and weighed as W4.

Formulas:

1.Specific gravity = W4 / W3-(W1-W2)

2.Water Absorption = W3-W4 / W4 X 100

Calculations:

For coarse aggregates,

Specific gravity = 2179/2200 – (1534-156)

= 2.65

Water Absorption = 2200-2179/2179 x 100= 0.96

Test results	Natural Aggregates	
Size	Fine aggregates	Coarse aggregate
Specific gravity	2.65	2.68
Water absorption (%)	0.96	0.98

Table No.5.1

Results of specific gravity test on Natural Aggregate

Concrete Mix Design

The Indian Standard Method (IS) adopted for concrete mix design as per IS 10262:2009

Data required for mix proportioning is as follows:

1	Design Grade of concrete	M20
2	Characteristic strength of concrete (MPa)	20
3	Target mean strength (MPa)	26.6
4	Exposure conditions	Mild
5	Type of cement	OPC 43 grade
6	Nominal size of aggregates	20mm
7	Specific Gravity of cement	3.15

Table No.5.2
General data for mix design

Design for M-20 concrete

Type of exposure: Mild

Fck = fck + ts

Fck = 20 + (4 * 1.65)

Fck = 26.6 N / mm^2

From graph w/c ratio = 0.55-0.05 = 0.5

Selecting w/c ratio as 0.5,

Selecting maximum size of aggregate as 20 mm, so the entrapped air 2 %,

Net volume of concrete = 100 - 2 = 98 %

Water content (for 20 mm) = 186 kg

for every 25 mm add 3% (IS-10262-cl.5.3)

186+6% of 186 = 197 kg

For super plastisizer reduce 20% (197-20% of 197) = 157.6 kg

Water content = 157.6 kg

Calculation of cement content

Cement content = water content / water cement ratio

157.6 / 0.5 = 315 kg/m3 > 300 kg/m3

Cement content = 315 kg/m3

Aggregate proportion between C.A. & F.A.

For zone - II – 0.62 (w/c – 0.5)

Every 0.05 increase reduce 0.01

0.62-0.01 = 0.61

For pumpable concrete C.A. can be reduced upto 10%

Volume of coarse aggregate = 0.61-(10% of 0.61) = 0.549

Mix calculation -

a) Volume of concrete- 1 m3
b) Volume of cement (mass / specific gravity) x (1/1000)

= 315/(3.16 x 1000) = 0.099 m3

c) Volume of water = (mass / specific gravity) x (1/1000)

= 157.6/(1 x 1000) = 0.158 m3

d) Volume of admixture = (mass / specific gravity) x (1/1000)

(1.1/100) x 315/(1.12x1000) = 0.0031 m3

e)Volume of all in aggregate

1-(b + c + d)= 1 - (0.099+0.158+0.0031) = 0.740

f) Mass of coarse aggregate

Volume of all in aggregate x Volume of C.A. x Specific gravity of C.A. x 1000

0.740 x 0.549 x 2.73 x 1000 = 1110 kg

g) Mass of fine aggregate

Volume of all in aggregate x Volume of F.A. x Specific gravity of F.A. x 1000

0.740 x 0.451 x 2.46 x 1000 = 821 kg

Material	**Proportions**	**Per cubic volume**
Water	0.5	157.6kg/m3
Cement	1	315 kg/m3
Fine aggregate/Sand	2.63	821 kg/m3
Coarse aggregate	3.56	1110 kg/m3
Admixture	1.1%	3.465 kg/m3
W/C ratio		0.5

Table No.5.3
Concrete Mix Design data
Replacement of Coarse Aggregate with Recycled Aggregate

Replacement	Weight of coarse aggregate
20%	222 kg/m3
30%	333 kg/m3
40%	444 kg/m3

- As per design, the quantity of all the materials forming the concrete was calculated.
- The materials were mixed by hand mixing and compaction was carried out mechanically followed by slump cone test to identify the workability of concrete.
- Concrete blocks of standard size **150mm X 150mm X150mm** casted with above concrete mix design to study the strength parameter of concrete.

• Type of Mix	7days(N/mm^2)	28days(N/mm^2)
Natural	14.9	22
20%	13.87	20.1
30%	13.56	19.9
40%	12.9	19

Table No.5.3
Results of compressive strength test on concrete with natural aggregates

Demolition Waste Characterization

The various tests conducted on the demolition waste to examine properties and characterization is done for safe and useful replacement with conventional concrete.

Collection of Demolition Waste

- The demolition waste is collected from the demolition site in Talegaon with concrete as major waste component which primarily consists of pieces of old concrete, paper sheets, furniture pieces, rubber and plastic etc.

The collected demolition waste is taken to laboratory for further processing**.**

Sorting and Crushing of Demolition Waste

- The pieces of concrete are separated out from the demolition wastes which are useful for recycling concrete.
- Manual separation with hands using hand gloves is adopted for separation of other matter from demolition waste.
- After sorting the demolition waste is crushed manually with hammers to the standard size of aggregates.
- For small quantity, manual crushing is adopted on industrial level various types of mechanical crushers can be used for ease in operation.

Properties of Demolition Waste

Test for particle size and shape

This test was planned and performed following procedure was adopted.

- After crushing operation, the obtained recycled concrete aggregates are thoroughly wetted and surface dried in order to remove dust, dirt etc.
- All recycled concrete aggregates are less than 10mm (IS Sieve) and major quantity of recycled concrete aggregates are less than 4.75mm (IS Sieve).
- Sieve analysis on recycled concrete aggregate is performed in order to classify it according to Indian Standard Classification.

Conditions prevailing need of an admixture

As per test results: -

- The concrete with recycled concrete aggregates was not homogenous.
- The water absorption of recycled concrete aggregates was high as compared to natural aggregates.
- Low homogeneity resulting in formation of rough surface of concrete with number of voids.
- Self-compaction of concrete with recycled concrete aggregates was low as compared to conventional concrete due high water

absorption of recycled concrete aggregates.

- As more water was absorbed by recycled concrete aggregates, low rate of hydration of cement was observed.

Considering all the above mentioned factors and results the use of admixture was found suitable in concrete with recycled concrete aggregate.

The properties of admixture **Sika Viscocrete 5210 NS** was satisfactory to overcome all above factors with easy availability in market, hence selecting the same in design of concrete with recycled concrete aggregates.

Properties of Sika Viscocrete 5210 NS

With the use of Sika Viscocrete 5210 NS we can:

- Improve dispersion properties
- Reduced water absorption rate
- Improve strength, density, durability and cohesion properties
- Improve flow ability i.e. workability
- Reduced drying shrinkage

Sika Viscocrete 5210 NS helps to improve characteristics concrete such as:

- High performance concrete
- High strength concrete
- Self-compacting concrete

Dosage: 0.3-2.0% by weight of cement

CONCLUSION

The strength of concrete blocks casted using 20% RCA gives better reults as compared to other proportions. The desired strength is achieved by adding admixture Sika ViscoCrete-3110 W.

This investigation examined the main physical properties and composition of recycled aggregates (RA) for use in concrete and undertook a statistical analysis of data available in the literature review.

The main conclusions that can be drawn from this study are:-

Selective demolition should be promoted and enforced whenever possible. This is an absolute necessity if we want to obtain material with minimum level of contamination, thereby adding value to the recycled aggregates product for is use in constructions.

The compositions and the physical properties of an RA should be determined prior to its acceptance for use in concrete productions. This, besides making its classification easier, will allow a better understanding of the material and its likely performance, facilitated its certification and help boost stakeholder confidence.

When properly processed and categorized, RA may be constructed as another type of normal aggregate, fit for use in constructions as per national and international specification.

There have been several possible applications of demolished waste in construction industry. However, probably due to lack of systematic studies enough data is still not available for its wide spread uses in construction.

Using crushed concrete in fresh concrete decreases the demolished waste in the country, but also it will decrease the use of river sand, which is becoming hard to come by, and also it will make the construction much cheaper.

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