AN EXPERIMENTAL STUDY ON UTILIZATION OF DEMOLISHED CONCRETE WASTE FOR NEW CONSTRUCTION

M. Anjaneyulu Naik[1], A. Ramakrishnaiah[2],
[1]PG Student, Dept. of Civil (structural engineering and Construction Management), Golden Valley Integrated Campus, Madanapalli, Chittoor, Andhra Pradesh, India.
[2]Associate professor, Dept. of civil engineering, Golden Valley Integrated Campus, Madanapalli, Chittoor, Andhra Pradesh.

ABSTRACT: In present day scenario Demolished Concrete waste handling and management is challenging job for all civil engineers all over the world. Recycling the Demolished Concrete will reduce the environmental pollution and protects the natural resources. This research is focused on utilizing the Demolished Concrete waste and reducing the generation of construction waste, and collecting Demolished Concrete from the demolition of building at site, Crushing Demolished Concrete waste and separating different sizes using sieve analysis, by collecting various sizes of Aggregate are treated with heating and chemical process. In recent years demolished concrete waste handling and management is the new primary challenging issue faced by all the countries. It is very challenging and hectic problem that has to be tackled in an indigenous manner, it is desirable to completely recycle demolished concrete waste in order to protect natural resources and reduce environmental pollution. In my research paper an experimental study is carried out to investigate the feasibility and recycling of demolished waste concrete for new construction

I. INTRODUCTION

Concrete has been around for many centuries the first known use of a material resembling concrete was found by the Minoan civilization around 2000 BC. During the earlier stages of the Roman Empire around 300 BC, the Romans discovered that mixing a sandy volcanic ash with lime mortar created a hard water resistance substance which we know as concrete. A huge amount of solid waste is generated annually from construction and demolition activities. This has lead to the promotion of waste recycling as a major measure to reduce waste and to mitigate the harmful effects of construction activities on the environment. Among these waste, concrete apportions more than half of the total. The construction industry conspicuous consumer of raw material of many types and thus large material inventories are required to sustain the growth. Among the various raw materials used in construction, aggregates are important components for all the construction activities and the demand in 2007 has seen increase by 5%, to over 21 billion tones the largest being in developing countries like china, India etc. The use of swine manure, animal fat, silica fume, empty palm fruit bunch, citrus peels, fly ash, foundry sand, glass, plastic, carpet, and concrete aggregate in construction is becoming increasingly popular due to the shortage and increasing cost of raw materials. This study presents an initial understanding of the current strengths and weaknesses of the practices intended to support construction industry in developing effect policies regarding uses of waste and recycled materials as construction materials.

INTRODUCTION TO DEMOLISHING:

India is presently generating construction and demolition (C & D) waste to the tune of 23.75 million tones annually and these figures are likely to double fold in the next 7 years. C & D waste and specifically concrete has been seen as a resource in developed countries. Works on recycling have emphasized that if old concrete has to be used in second generation concrete, the product should adhere to the required compressive strength. This paper deals with the review of the existing literature work for the use of recycled concrete as aggregates in concrete in respect of mainly the compressive strength and proposes and approach for use of recycled concrete aggregate without compromising the strength. The need for demolition, repairs and renewal of concrete and masonry structures is rising all over the world, more so in the developing countries.

STEPS INVOLVED IN DEMOLISHING

Normally, the building which is going to be demolished is less than 1750 cubic feet then it doesn't need any permission for the demolition. Now, coming to the demolition then it is a process destroying a building after its life period with the aid of few tools or by using other methods. In the process of demolition, if the explosives are used then such a process is called as the implosion. Each and every structure of the civil engineering has a certain period of life and after that, it has to be demolished by following the safety measures, the distinct steps are involved in the process of demolition at the time of the process of demolition.

Fig.: Demolishing Structure with Equipment

The distinct steps that are required before performing the process of demolition are as below:

- Surveying
- Removing the dangerous materials
- Preparation of the plan
- The report of stability
- The necessary safety measures

THE INDIAN SCENARIO

Indian construction industry is highly employment intensive and accounts for approximately 50% of the capital out lay in successive 5-year plans of our country. The projected investment in this industrial sector continues to show a growing trend. Central Pollution Control Board has estimated current quantum of solid waste generation in India to the tune of 48 million tons/annum of which waste from construction industry accounts for 25%. The total quantum of waste from construction industry is estimated to be 12 to 14.7 million tons per annum.

OBJECTIVES

The aim of this study was not only to find out utilization of waste materials on concrete in order to compare them from the economic point of view but also to investigate the feasibility of using materials from deconstructed buildings. It's hoped that the findings of such study will encourage professionals to use second hand components in new buildings/constructions. Objective The objectives of this research are following as-

1. To use of the demolished and construction waste aggregate in the new concrete as the recycled concrete aggregate reduces the environmental pollution as well as providing an economic value for the waste material.
2. To study the utilization of demolished and construction waste as a replacement of natural coarse aggregate.
3. To study the mechanical and physical properties of demolished and construction waste aggregate by conducting experimental work.

II LITERATURE REVIEW

Asif Husain1 , Majid Matouq Assas2 et al.,(2013) states that the use of dismantled aggregate in making fresh concrete will also help in reduction of solid waste dumping on existing landfill sites. The reuse of dismantled concrete will help in improvement of overall environment of the region. Firstly, by reduction in mining and secondly reduction in air pollution resulting from production of aggregates (dust pollution) and transportation of aggregate from mining to consumption point (vehicular pollution). Thus, study shows that dismantled concrete is not solid waste but useful material to be recycled to prepare fresh concrete, which saves the cement and make the concrete economical.

Goudappa Biradar1 et al., (2015) states that the recycled aggregates that are obtained from concrete specimen make good quality concrete. For improving the quality of recycled coarse aggregate, various surface treatment methods such as washing the recycled aggregates with water and diluted acid were investigated. Mix designs can be made using recycled aggregate for structural concrete elements instead of disposing off the recycled concrete to achieve economy.

R. Kumutha1 , K. Vijai2 et., (2010) states that the possibility of using recycled aggregates as the replacement of natural coarse aggregates or fine aggregates in concrete. A series of tests were carried out to determine the density, compressive strength, split tensile strength, flexural strength and modulus of elasticity of concrete with and without recycled aggregates. Natural coarse aggregates in concrete was replaced with 0%, 20%, 40%, 60%, 80% and 100% of crushed concrete aggregates. Natural fine aggregate in concrete was replaced with 0%, 20%, 40%, 60%, 80% and 100% of crushed brick aggregates. Recycled concrete aggregate can be used as base and sub base materials, in place of crushed stone aggregate, for supporting a concrete pavement system.

The compatibility of recycled concrete aggregate is the same as that of crushed stone aggregate and gravel aggregate.

Sivakumar et al. (2004) conducted repeated load tests in a direct shear apparatus on crushed concrete and building debris and concluded that recycled construction wastes have significant shear strength and these materials could be utilized in various geotechnical applications. It was also stated that a careful consideration must be given to the suitability of these materials in civil engineering applications where the loading conditions are intensive.

Winston F. K. Fong et al. (2004) after conducting case studies discussed the latest application experience of using recycled aggregate in construction projects in Hong Kong and concluded that the recycled aggregates have been demonstrated to be able to produce quality concrete for structural applications. It was also stated that more research and development is needed to further promote the recycling concept and widen the scope of applications of recycled aggregates.

Oikonomou (2005) proposed a guidance of tests and limits of recycled concrete aggregate in order to be used as a basis for pilot and long 13 scale works where the use of recycled concrete aggregate can be estimated as more economic and friendlier to the environment.

III MATERIALS

In making any type of concrete, selection and type of materials is very important as all the properties depends on them. The following materials are being used and are listed below.

Cement

Fine aggregate (sand)

Coarse aggregate replaced with Recycled coarse aggregate (RCA)

Water

CEMENT

The most common cement used is an Ordinary Portland Cement (OPC). The Ordinary Portland Cement of 53 grade (OPC) conforming to IS: 8112-1989 is used. It is a powered adhesive and cohesive substance which when mixed with fine aggregate, coarse aggregate and water form a paste which on curing for certain period turns in to mass of hard stone. Proper selection of cement is utmost important as the strength of concrete mostly depends on it. The properties of cement are shown in Table.

Fig.: Cement

Table: 3.1. Properties of Cement

S.No.	CHARACTERISTICS	VALUE
1	SPECIFIC GRAVITY	3.15
2	NORMAL CONSISTENCY	31%
3	INITIAL SETTING TIME	82 minutes
4	FINAL SETTING TIME	205 minutes

Aggregates

Aggregates are inert granular materials such as sand, gravel or crushed stone that are an end product in their own right. They are also the raw materials that are an essential ingredient in concrete. For a good concrete mix, aggregates need to be clean, hard, strong particles free of absorbed chemicals or coatings of clay and other fine materials that could cause the deterioration of concrete.

Depending upon the size the aggregates are classified into two types
Fine Aggregate
Coarse Aggregate

Fine Aggregate

Fine aggregate are basically sands won from the land or the marine environment. Fine aggregates generally consist of natural sand or crushed stone with most particles passing through a 9.5mm sieve. As with coarse aggregates these can be from Primary, Secondary or Recycled sources. The selection of fine aggregate is also on important factor as it directly affects the strength of concrete with the varying utilization of water.

Table: Properties of Fine Aggregate.

S.No.	CHARACTERISTICS	VALUE
1	ZONE	II
2	SPECIFIC GRAVITY	2.64
3	DENSITY	14KN/m^3

Coarse Aggregate

Coarse aggregates are particles greater than 4.75mm, but generally range between 9.5mm to 37.5mm in diameter. They can either be from Primary, Secondary or Recycled sources. Primary, or 'virgin', aggregates are either Land- or Marine-Won. Gravel is a coarse marine-won aggregate; land-won coarse aggregates include gravel and crushed rock. Gravels constitute the majority of coarse aggregate used in concrete with crushed stone making up most of the remainder.

Table: Properties of Coarse Aggregate.

S.No.	CHARACTERISTICS	VALUE
1	NOMINAL SIZE	10mm
2	SPECIFIC GRAVITY	2.84
3	DENSITY	1625.83Kg/m^3

Recycled Aggregates

The waste from the demolition of concrete structures are collected, aggregates are separated as recycled aggregates. The proposed recycled aggregates are used in the concrete mix for this project. The recycled aggregates are conformed by means of grading. As per specification 20 mm angular recycled aggregates are selected for partial replacement.

PROPERTIES OF RECYCLED AGGREGATE

The use of recycled aggregate obtained from the waste concrete, as a component of the new concrete mixture, implies a thorough understanding of its basic properties, considering that some of them may significantly differ from the properties of aggregates obtained from natural resources. In addition, their differences primarily depend on the quantity and quality of cement mortar, which is attached to the grains of recycled aggregate, then, on the quality of the original concrete from which the aggregate is made by recycling and also on recycling methods. Nonetheless, in cases where the recycled aggregate comes from many different sources, the uneven quality, i.e. variations in the properties of recycled aggregate are much more pronounced than as is the case with natural aggregates

Fig.: Collection of recycled aggregate

Table: Physical Properties

S.No.	Physical Properties	RCA
1	Water absorption (%)	1.56
2	Specific gravity	2.63
3	Bulk Density (kg/ m 3)	1469.8

Water

Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement. Since it helps to from the strength giving cement gel, the quantity and quality of water is required to be looked into very carefully. Water cement ratio used is 0.40 for M25

MIX PROPORTIONS

The concrete mix is designed as per IS: 10262 – 2009 and IS 456-2000 for the normal concrete. The grade of concrete adopted is M25 with a water cement ratio of 0.45. Replacement of NCA with RCA.
The following points should be remembered before proportioning a concrete mix as per IS-10262-2009.

- This method of concrete mix proportioning is applicable only for ordinary and standard concrete grades.
- The air content in concrete is considered as nil.

The proportioning is carried out to achieve specified characteristic compressive strength at specified age, workability of fresh concrete and durability requirements.

Table: Mix proportions values.

Mixture	A0	A1	A2	A3	A4	A5
Cement	448.6	448.6	448.6	448.6	448.6	448.6
Coarse Aggregate (Kg/m^3)	1064.65	1064.65	1064.65	1064.65	1064.65	1064.65
Replacement of coarse with recycled aggregate.	0%	20%	40%	60%	80%	100%
Fine Aggregate (Kg/m^3)	752.71	752.71	752.71	752.71	752.71	752.71
Water (lit)	197.4	197.4	197.4	197.4	197.4	197.4

Table: Mix proportions details

Mix	Mix details
A0	NORMAL CONCRETE (100%)
A1	20% RCA +80% NCA
A2	40% RCA +60% NCA
A3	60% RCA +40% NCA
A4	80% RCA +20% NCA
A5	100% RCA +0% NCA

Casting of cube specimens

Curing cube specimens

IV EXPERIMENTAL INVESTIGATION

COMPRESSIVE STRENGTH TEST

Concrete cubes of sizes 150mm×150mm×150mm were tested for crushing strength. Compressive strength depends on loads of factor such as w/c ratio, cement strength, excellence of concrete material and excellence control during manufacture of concrete.

These cubes are tested by compression testing machine after 7 days, 14 days or 28 days curing. The sample is placed centrally on the base plate of machine and the load have to be apply gradually at the rate of 140 kg/cm2 per minute till the specimen fails. Load at the failure separated by area of sample gives the compressive strength of concrete. The sample to increased load breaks down and no greater load greater load can be constant. The maximum load applied to specimen shall then be recorded and any unusual value noted at the time of failure brought out in the report.

The cube compressive strength, then f_c=P/A N/mm^2

Where P is an ultimate load in N, A is a cross sectional area of cube in mm^2

Fig. Compressive Strength Test

SPLIT TENSILE STRENGTH OF CONCRETE

The tensile strength of concrete is one of the basic and important properties. Splitting tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete. The concrete is very weak in tension due to its brittle nature and is not expected to resist the direct tension. The concrete develops cracks when subjected to tensile forces. Thus, it is necessary to determine the tensile strength of concrete to determine the load at which the concrete members may crack.

Splitting tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete. Split tensile strength test was conducted by using the method prescribed by IS5816-1999. Cylinders of 150mm×300mm were used for this test. The specimens were tested for 7, 14, 28 days the cylinder specimen was placed in horizontal direction on the testing machine.

The splitting of cylinder is shown in figure. The following relation is used to find out the spilt tensile strength of cylinder

$$F_t = \frac{2P}{\pi DL}$$

Where F_t is split tensile strength,

P= Ultimate load in KN

L = Length of the cylinder in mm, D = Diameter of the cylinder in mm

Fig.: Split Tensile Strength Testing Machine.

FLEXURE STRENGTH TEST

Flexural strength test on concrete beam to determine the strength of concrete. Flexural strength test was conducted by using the method prescribed by IS 516 – 1959.

Beams of dimension 700mm×150mm×150mm were used for this test, the test specimen is placed in the machine at the bearing surfaces of the supporting and loading rollers. So that the load shall be applied without shock and increasing continuously at a stress increases at approximately 7 kg/sq mm that is at a rate of loading 400 kg/min for the 150 mm specimens. The load shall be increased until the specimen fails, and the maximum load applied to the specimen during the test shall be recorded.

Where, Modulus of rupture f = PL/BD^2

P is the load in KN.

L, B is the length and breadth in mm.

D is the depth in mm.

f is the flexure strength in N/mm^2

Fig.: Flexural Strength Testing Machine.

V EXPERIMENTAL RESULTS

The results completed in the present investigation are reported in the form of Tables and Graphs for various percentage of recycled aggregate as a replacement to coarse aggregate. The following are the percentages replacement of cement i.e. 20%, 40%, 60%, 80%, 100%.

SLUMP TEST

Slump test is used to determine the workability of fresh concrete. Slump test as per IS: 1199 – 1959 is followed. The apparatus used for doing slump test are Slump cone and Tamping rod.

The internal surface of the mould is thoroughly cleaned and applied with a light coat of oil. The mould is placed on a smooth, horizontal, rigid and non-absorbent surface. The mould is then filled in four layers with freshly mixed concrete, each approximately to one-fourth of the height of the mould. Each layer is tamped 25 times by the rounded end of the tamping rod (strokes are distributed evenly over the cross section). After the top layer is rodded, the concrete is struck off the level with a trowel

Table: SLUMP TEST RESULT

S.No.	Type of concrete MIX -ID	SLUMP IN mm
1	A0	25.5
2	A1	22
3	A2	24
4	A3	26
5	A4	25
6	A5	23

Fig.: Compressive Strength test results

COMPRESSIVE STRENGTH RESULTS

Table.: COMPRESSIVE STRENGTH TEST RESULT

Mix ID	% recycled aggregate	Compressive strength at Age of 7 days, MPa	Compressive strength at Age of 14 days, MPa	Compressive strength at Age of 28 days, MPa	Compressive strength at Age of 56 days, MPa
A0	0	19.2	28.4	30.2	31.8
A1	20	25.2	29.2	30.4	32.4
A2	40	19.8	26.4	29.5	33.0
A3	60	29.4	30.2	32.4	36.5
A4	80	26.5	28.8	30.8	32.5
A5	100	27.5	28.5	31.2	30.8

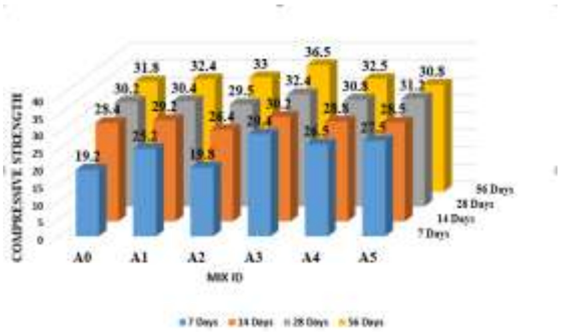

Fig.: Compressive Strength test results

SPLIT TENSILE STRENGTH TEST RESULTS

Table.: SPLIT TENSILE STRENGTH TEST RESULT

Mix ID	% recycled aggregate	Tensile strength at Age of 7 days, MPa	Tensile strength at Age of 14 days, MPa	Tensile strength at Age of 28 days, MPa	Tensile strength at Age of days, MPa
A0	0	1.98	2.02	2.58	2.85
A1	20	2.52	2.62	2.87	2.98
A2	40	2.68	2.832	2.92	3.01
A3	60	2.98	3.08	3.19	3.32
A4	80	2.71	2.78	2.89	2.98
A5	100	1.98	2.08	2.19	2.32

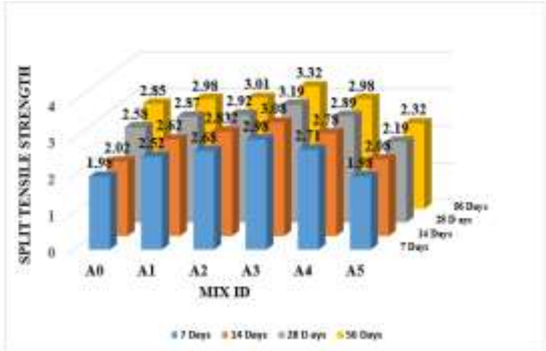

Fig.: Split Tensile Strength test results

Table.: FLEXURAL STRENGTH TEST RESULT

Mix ID	% recycled aggregate	Flexural strength at Age of 7 days, MPa	Flexural strength at Age of 14 days, MPa	Flexural strength at Age of 28 days, MPa	Flexural strength at Age of 56 days, MPa
A0	0	9.55	9.62	9.8	10.15
A1	20	9.632	9.85	9.92	10.5
A2	40	9.76	9.97	10.2	10.8
A3	60	9.8	10.4	10.8	11.2
A4	80	9.75	9.82	10.12	10.62
A5	100	9.52	9.6	9.8	10.35

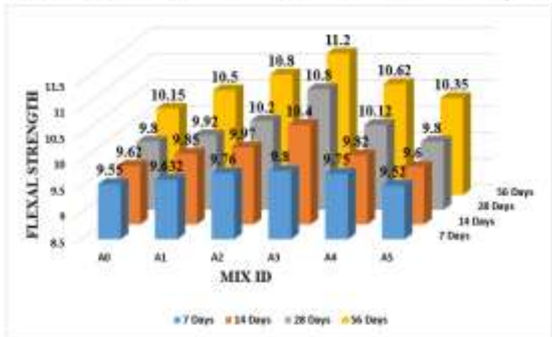

Fig.: Flexural Strength test results

Table : TEST RESULTS

NAME OF THE TEST		A0	A1	A2	A3	A4	A5
COMPRESSION STRENGTH	7 DAYS	19.2	22.2	19.8	29.4	26.5	27.5
	14 DAYS	28.4	29.2	26.4	30.2	28.8	28.5
	28 DAYS	30.2	30.4	29.5	32.4	30.8	31.2
	56 DAYS	31.8	32.4	33.0	36.5	32.5	30.8
SPLIT TENSILE STRENGTH	7 DAYS	1.98	2.52	2.68	2.98	2.71	1.98
	14 DAYS	2.02	2.62	2.832	3.08	2.78	2.08
	28 DAYS	2.58	2.87	2.92	3.19	2.89	2.19
	56 DAYS	2.85	2.98	3.01	3.32	2.98	2.52
FLEXURAL STRENGTH	7 DAYS	9.55	9.632	9.76	9.8	9.75	9.52
	14 DAYS	9.62	9.85	9.97	10.4	9.82	9.6
	28 DAYS	9.8	9.92	10.2	10.8	10.12	9.8
	56 DAYS	10.15	10.5	10.8	11.2	10.62	10.35

V CONCLUSION

Based on limited experimental investigation concerning the strength tests i.e. compression, split tensile and flexural strength the following observations are regarding the resistance of replacement done with RCA to NCA in M25 concrete:

Concrete recycling will become one of the most important elements for construction sustainability. Concrete in which binders, additives and aggregates are all made of cement or materials of cement, and all of these materials can be used as raw materials of cement after hardening. Concrete which contains waste products as aggregate is called 'Green' concrete. This paper focuses on the feasibility of construction waste aggregate to making new green concrete. Various standard tests were carried out using recycled aggregate such as Based on limited experimental investigation concerning the strength tests i.e. compression, split tensile and flexural strength the following observations are regarding the resistance of replacement done with RCA to NCA in M25 concrete:

 Demolished aggregate possesses relatively lower bulk crushing, density and impact standards and higher water absorption as compared to natural aggregate.
 Using demolished aggregate concrete as a base material for roadways reduce the pollution involved in trucking material.
 The compressive strength of the concrete is increases with increasing the percentage of demolished material upto 30%.
 The split tensile and flexural strength of demolished concrete is also increases with increasing the percentage of demolished material.
 The use of dismantled aggregate in making fresh concrete will also help in reduction of solid waste dumping on existing landfill sites.
 The reuse of dismantled concrete will help in improvement of overall environment of the region. Firstly, by reduction in mining and secondly reduction in air pollution resulting from production of aggregates (dust pollution) and transportation of aggregate from mining to consumption point
 The idea of reusing the waste material is very exciting and encouraging specially when it will be helpful in minimizing destruction to earth's crust and green forest cover by virtue of reduced mining.

SCOPE OF FUTURE WORK

- Further research should be carried out to confirm the beneficial effects of RCA on several concrete properties and durability issues, and thus to encourage the use of RCA replacement of coarse aggregate in concrete.
- Additional research should be conducted to extend the use of RCA in high performance and self-consolidating concretes.
- SCC is favourably suitable especially in highly reinforced concrete members like bridge decks or abutments, tunnel linings or tubing segments, where it is difficult to vibrate the concrete, or even for normal engineering structures. So introducing RCA in SCC leads to better results.
- The improved construction practice and performance, combined with the health and safety benefits, make RCA a very attractive solution for both precast concrete and civil engineering construction.

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