# Concept of Green Concrete Using Construction Demolished Waste As Recycled Coarse Aggregate

**Prof. Chetna M Vyas[1], Prof. (Dr.) Darshana R Bhatt[2]**

[1] *Assistant Professor, Civil Engg. Dept, A.D.I.T, New Vallabh Vidhyanagar – Gujarat – India*
[2]*Associate Professor, Structural Engg. Dept., B.V.M Engineering College, Vallabh Vidhyanagar – Gujarat – India*

**ABSTRACT:The use of Recycle product is increasing with innovation in present scenario. The utilization of waste product in the manufacturing of new product is a challenging job. The Natural Resource decreases in a short period and therefore the use of waste product is necessary. There are a number of old buildings and structures are demolished today. The reuse of that demolished debris is a good solution to the problem of an excess of waste material. The studies on the use of recycled aggregates have been going on for few years.Aggregates play important role in strength characteristic of concrete. This paper focuses on the possibility of the use of recycled coarse aggregate concrete as a new structural material.For that purpose a literature survey for use of recycled aggregate concrete is studied. Recycled coarse aggregate (RCA) obtained from crushed concrete rubble and different demolished work. Instead of being stored, it can be reused in the building industry.Recycled aggregates are comprised of crushed, graded inorganic particles which are obtained from demolition debris. The aim of this research project is to determine the strength characteristic of recycled coarse aggregate concrete by using different percentage of recycled aggregates in M45 Grade.The results with 40% use of recycled coarse aggregates give workable, strong and green concrete.**

**KEYWORDS-** Recycled coarse aggregate, Recycled coarse aggregate concrete, compressive strength, workability, Green Concrete.

## I INTRODUCTION

Inrecent years, the recycling of waste product is necessary to produce new product suitable for the environment. Infrastructure department is the second largest sector after agriculture in India. Concrete is the world's most widely used construction material. The continuously growing demand for concrete to meet the "exploding" infrastructure development worldwide is not without any negative impacts on the environment and on our future capacity for development. The management of construction and demolition waste is a major concern due to increased quantities of demolition rubble, the continuing shortage of dumping sites, increase in the cost of disposal and transportation and above all the concern about environmental degradation. The global construction industry uses billions tons of cement and billionstons of sand, gravel, and crushed rock every year. The use of waste materials as a source of aggregate in new construction materials has become more common in recent decades. The depletion of the existing landfills and the scarcity of natural resources for aggregates encourage the use of construction and demolition waste as a source of aggregates in the production of new concrete. Aggregate is important material for the strength of concrete. The strength of concrete is depending on quality, shape and size of aggregates used in concrete. The natural recourses are decrease in short period. The use of demolished waste material as the basic material of new construction is more economic and ecofriendly. This research work considers the comparison of properties of Recycled Coarse Aggregate and Natural Coarse Aggregate like water absorption and specific gravity, mechanical properties, such as abrasion resistance, impact values and crushing values.

Workability of fresh concrete and strength parameters of hardened concrete, such as compressive strength were studied. The preceding properties were tested for three different periods of curing of 3, 7, and 28 days. All these mixes were designed for M45 grade of concrete. In the present work, a comparison was made between the results of a laboratory investigation on various physical properties of concrete made with recycled aggregate concrete with fresh aggregate concrete and found that the results are encouraging to use concrete with RCA.

By using waste product of construction we prepared the concrete which is eco-friendly and saves the environment.Use of green concrete helps in saving energy, emissions, waste water Green concrete is very often also cheap to produce as it uses waste products directly as a partial substitute. Over and above all green concrete has greater strength and durability than the normal concrete.

## II EXPERIMENTAL MATERIALS

a. **Cement**

The most common cement used is an ordinary Portland cement. The Ordinary Portland Cement of 53 grades conforming to IS: 8112-1989 is beingused. Many tests were conducted on cement; some of them are consistency tests, setting tests, soundness tests, etc.

**TABLE-1**
**PROPERTIES OF ORDINARY PORTLAND CEMENT 53 GRADE**

| Sr. No | Physical properties of OPC 53Cement | Results | Requirements as per IS:8112-1989 |
|---|---|---|---|
| 1 | Specific Gravity | 3.15 | 3.10-3.15 |
| 2 | Standard consistency (%) | 31.5 | 30-35 |
| 3 | Initial Setting Time (min) | 30 | 30 minimum |
| 4 | Final Setting Time (min) | 211 | 600 maximum |
| 5 | Compressive Strength (At 28 days in N/mm2) | 58 | 53 $N/mm^2$ minimum |

**a) Aggregates**

Aggregates are the important and large used constituents in concrete. They give bond to the concrete, reduce shrinkage and effect economy. One of the most important factors for producing workable concrete is a good gradation of aggregates. It indicates that fractions of aggregates in required proportion such that the sample contains minimum voids. Samples of the well graded aggregate containing minimum voids require minimum paste to fill up the voids in the aggregates. Minimum paste means less quantity of cement and less water, which are further mean increased economy, higher strength, lower shrinkage and greater durability

**b) Coarse Aggregate (Recycled and Natural Coarse Aggregates)**

The fractions from 20 mm to 4.75 mm are used as coarse aggregate. The Coarse Aggregates from crushed Basalt rock, conforming to IS: 383 is being used. The Flakiness and Elongation Index were maintained well below 15%.

**Figure: 1Recycled Aggregate and Natural Aggregate**

**COMPARISON OF RECYCLED AND NATURAL AGGREGATE:**

❖ **Texture**

Recycled aggregate has the rough – textured, angular and elongated particles where natural aggregate is smooth and rounded compact aggregate. The properties of the freshly mixed concrete will be affected by the particle shape and surface texture of the aggregate. The rough – texture, angular and elongated particles require much water than the smooth and rounded compact aggregate when producing the workable concrete. The void content will increase with the angular aggregate where the larger sizes of well and improved grading aggregate will decrease the void content.

❖ **Quality**

The quality is different between recycled aggregate and natural aggregate. The quality of natural

aggregate is based on the physical and chemical properties of sources sites, where the recycled aggregate is depended on contamination of debris sources. It also stated that natural resources have suitable for multiple product and higher product larger marketing area, but recycled aggregate have limited product mixes and the lower product mixes may restrain the market.

❖ **Density**

The density of the recycled concrete aggregate is lower than natural aggregate. Density of recycled aggregate is lower than the fresh aggregate because of the porous and less dense residual mortar lumps that is adhering to the surfaces. When the particle size is increased, the volume percentage of residual mortar will increase too.

❖ **Strength**

The strength of recycled aggregate is lower than natural aggregate because of the weight of recycled aggregate is lighter than natural aggregate. This is the general effect that will reduce the strength of reinforced concrete.

**TABLE -2**
**PROPERTIES OF NATURAL & RECYCLED AGGREGATES**

| Property | Coarse Aggregate | Recycled Coarse Aggregate |
|---|---|---|
| Fineness modulus | 7.54 | 7.476 |
| Specific Gravity | 2.76 | 2.74 |
| Water absorption(%) | 1.83 | 1.73 |
| Bulk Density (gm/cc) | 1741 | 1660 |

**Aggregate Crushing value:**

The aggregate is placed in a cylindrical mould and a load of 40 ton is applied though a plunger. The material crushed to finer than 2.36 mm is separated and expressed as a % of the original Wt. taken on mould. The % is referred as aggregate crushing value. The crushing value of aggregate is rather insensitive to the variation in weaker aggregate. This is so because having been crushed before the application of the full load of 40 ton, the weaker materials become complicated, so that the amount of crushing during later stages of the test is reduced. When the aggregate crushing value becomes 30 or higher, the result is likely to be inaccurate, in which case the aggregate should be subjected to 10% fine value test which gives a better picture about the strength of such aggregate.

**TABLE 3**
**CRUSHING TEST VALUE**

| | 2.36mm passing (gm) | Total wt.(gm) | Crushing value (%) |
|---|---|---|---|
| NCA | 678gm | 3000gm | 22.6 |
| RCA | 554gm | 3228gm | 17.16 |

**Fine aggregate**

Those fractions from 4.75 mm to 150 microns are termed as fine aggregate. The river sand and crushed sand are used in combination as fine aggregate conforming to the requirements of IS: 383. The river sand is washed and screen, to eliminate deleterious materials and oversize particles.

**TABLE -4**
**PROPERTIES OF FINE AGGREGATE**

| Property | Fine Aggregate |
|---|---|
| Fineness modulus | 3.35 |
| Specific Gravity | 2.38 |
| Water absorption (%) | 1.20 |
| Bulk Density (gm/cc) | 1753 |

**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 are required to be looked into very carefully.

## III DESIGN MIX METHODOLOGY

A mix M45 grade was designed as per IS 10262:1989 and the same was used to prepare the test samples. The design mix proportion is shown in Table 5

**TABLE 5**
**CONCRETE DESIGN MIX PROPORTIONS**

| | Water | Cement | Fine Aggregate | Coarse Aggregate |
|---|---|---|---|---|
| By weight, [kg] | 181 | 517 | 504.64 | 1277.33 |

**TABLE -6**
**DETAILS OF M45 GRADE CONCRETE MIX**

| Mix | Recycled Course Aggregate |
|---|---|
| Mx1 | 0% |
| Mx2 | 20% |
| Mx3 | 40% |
| Mx4 | 60% |
| Mx5 | 80% |
| Mx6 | 100% |

## III EXPERIMENTAL WORK

This experimental study includes research work for the workability test and hardened concrete specimen test. The whole test program is as follows. The experimental study was divided into four major segments viz.

1) Materials and their testing

2) Concrete mix design

3) Checking the fresh properties of the mixes for M45 grade: Compacting factor test.

4) Tests on Hardened concrete specimens: Compressive Strength Test

## IV EXPERIMENTAL METHODOLOGY

Concrete contains cement, water, fine aggregate, coarse aggregate (Recycled and Natural). With the control concrete, i.e.0%, 20%, 40%, 60% and 100% of the natural aggregate is replaced with the recycled aggregates. Three cube samples were cast in the mould of size 150x150x150 mm for each 1:1.03:2.5 concrete mix with partial replacement of coarse aggregate with a w/c ratio as 0.50 were also cast. After about 24 h the specimens were de-moulded and water curing was continued till the respective specimens were tested after 7,14 and 28 days for compressive strength and workability tests.

**Compressive strength**

Compressive strength tests were performed on compression testing machine using cube samples. Three samples per batch were tested with the average strength values reported in this paper. The loading rate on the cube is 35 N/mm$^2$ per min. The comparative studies were made on their characteristics for concrete mix ratio of 1:1.03:2.5 with partial replacement of natural aggregate with recycled aggregates as 0%, 20%, 40%, 60%, 80% and 100%.

## V EXPERIMENTAL RESULTS

**TABLE -7**
**COMPACTION FACTOR VALUE FOR M45 GRADE MIX**

| Mix | Compaction Factor |
|---|---|
| Mx1 | 0.85 |
| Mx2 | 0.84 |
| Mx3 | 0.86 |
| Mx4 | 0.88 |
| Mx5 | 0.87 |
| Mx6 | 0.85 |

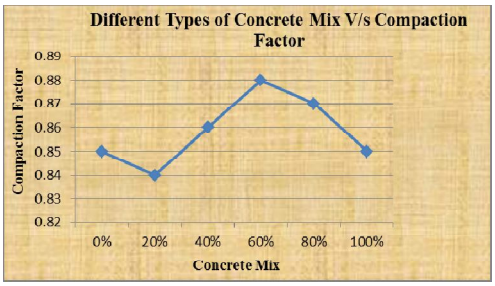


**Figure:2Different Types of Concrete Mix V/s Compaction Factor**

**TABLE -8**
**DIFFERENT TYPES OF CONCRETE MIX V/S COMPRESSIVE STRENGTH OF CUBES AT 3, 7 AND 28 DAYS**

| Sr. No | Mix | Average Compressive Strength in N/mm$^2$ | | |
|---|---|---|---|---|
| | | 3 Days | 7 Days | 28 Days |
| 1 | Mx1 | 29.73 | 37.78 | 49.29 |
| 2 | Mx2 | 28.40 | 34.11 | 43.50 |
| 3 | Mx3 | 27.90 | 35.40 | 47.96 |
| 4 | Mx4 | 24.29 | 32.72 | 40.28 |
| 5 | Mx5 | 23.94 | 31.63 | 39.51 |
| 6 | Mx6 | 22.67 | 30.40 | 38.28 |

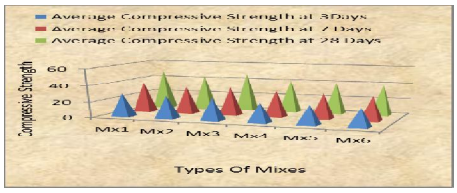


**Figure:3Different Types of Concrete Mix V/s Compressive Strength of Cubes**

**CONCLUSION:**

The utilization of waste demolition debris in new construction work is very important due to the materials waste is gradually increasing with the increase of population and urban development.

This Research work carried out different percentage of Recycled Coarse Aggregate with the partial replacement of Natural Coarse Aggregate. The investigation coversvarious test like compaction factor test and compressive strength test. The reasons that many investigations and analysis had been made on recycled aggregate are because recycled aggregate is easy to obtain and the cost is economic.

After detailed study of the result and analysis the following conclusions were made for M45 grade concrete.

a) The experimental results show that 0% to 40% replacement of Recycled Coarse Aggregate with the Natural Coarse Aggregate give enough compressive strength as per required.

b) Workability test of recycled coarse aggregate concrete is same as natural coarse aggregate. In a compaction factor test at also the replacement of 0% to 40% of Recycled Aggregate the compaction factor value is maximum; the highest compacting factor ratio is 0.90. So we can say that at the replacement of 40% recycled aggregate concrete is more workable.

c) A test resultof compression test indicates an increasing trend of compressive strength in the early age of the concrete specimens with 60% recycled aggregates. However, it shows that the strength of recycled aggregate specimens were gradually increased up to 40% replacement of recycled aggregate & then it decreases at the 100% replacement of recycled aggregate after 28 days. The target strength for M45 grade is 54.9 MPa that are achieved. The results also show that the concrete specimens with 40% replacement of recycled aggregate get the highest strength when compared to the concrete specimens with different percentage of recycled aggregate. From the obtained result, it is possible to use 40% recycled aggregate for a higher strength of concretes.

d) Hence the recycled aggregate can be used in concrete with 40% replacement of natural coarse aggregates to make Green Concrete.

**REFERENCES:**

[1] Mehta. P. K, Reducing the environmental impact of concrete, Concrete International, Vol: 23, No: 10,Oct 2001,pp-61-66.

[2] Vilas Nitivattananon and Guiberto Borongan (Sept 2007),"Construction and Demolition Waste Management: Current Practices in Asia", Proceedings of the International Conference on Sustainable Solid Waste Management,5-7thSept 2007,Chennai,India,pp-97-104

[3] M. Chakradhara Rao • S. K. Bhattacharyya ,S. V. Barai (April 2010)," Influence of field recycled coarse aggregate on properties of concrete ",Materials and Structures, DOI 10.1617/s11527-010-9620-x

[4] Hansen TC, Boegh E (1985)," Elasticity and drying shrinkage of recycled aggregate concrete". J ACI 82(5):648–652

[5] Hansen TC, Narud H (1983)," Strength of recycled concrete made from crushed concrete coarse aggregate". Concr Int Des Constr 5(1):79–83

[6] Tsung-Yueh,Yuen-YeunChen,Chao-Lung Hwang(2006),"Properties of HPC with recycled aggregates", Cement and Concrete Research,vol:36,pp943-950.

[7] J.S.Ryu,(2002),"An experimental study on the effect of recycled aggregate on concrete properties",Mag.Concr.Res,Vol:54(1),pp-7-12.

[8] Tsung-Yueh,Yuen-YeunChen,Chao-Lung Hwang(2006),"Properties of HPC with recycled aggregates", Cement and Concrete Research,vol:36,pp943-950.

[9] Neela eshpande,Dr.S.S.Kulkarni,(2011) "Critical analysis of recycled aggregate and concrete with recycled aggregate", Applied Mechanics and Materials,vol-99-100,pp-1274-1280

[10] Amnon Katz ( 2003),"Properties of concrete made with recycled aggregate from partially hydrated old concrete", Cement and Concrete Research,vol 33,pp 703-711.

[11] Ferguson, J.; Kermode, O.N.; Nash, C.L.; Sketch, W.A.J. and Huxford, R.P. (1995), "Managing and Minimising Construction

Waste," Institution of Civil Engineers, Thomas, Telford Publications, U.K., pp. 1-60.

[12] Hansen, T.C. (1992), "Recycling of Demolished Concrete Masonry, Rilem Report No. 6, E&FN Spon, London, Great Britain, pp. 316.

[13] Khatib JM,(2005)"Properties of concrete incorporating fine recycled aggregate". Cement Concrete Research,Vol: 35(4); pg-763-769.

[14] Mehta. P. K, (Oct 2001)"Reducing the environmental impact of concrete", Concrete International, Vol: 23, No : 10, pp-61-66.

[15] M. Chakradhara Rao, S. K. Bhattacharyya ,S. V. Barai (April 2010)," Influence of field recycled coarse aggregate on properties of concrete ",Materials and Structures, DOI 10.1617/s11527-010-9620-x

[16] Neela Deshpande (2011)"Effectiveness of using Coarse Recycled Concrete Aggregate in Concrete"

[17] Oikonomou,N.D.(2005)"Recycled Concrete Aggregates," Cement & Concrete Composites, Vol. 27, pp315-318.

**AUTHORS BIOGRAPHY**

Mrs. Chetna M. Vyas was born in 1964 in Umreth town. She received her Bachelor of Engineering degree in Civil (Structural) Engineering from the Birla Vishvakarma Mahavidyalaya in 1986. In 2000 she received her Master's Degree in Construction Engineering and Management from Birla Vishvakarma Mahavidyalaya, Sardar Patel University. She joined A.D.Patel Institute of Technology in 2002 as a faculty where she is Assistant Professor in Civil Engineering Department with a total experience of 25 years in the field of Research, Designing and education. She has papers published in National Conferences and International Journals.

Dr. Darshana R. Bhatt has completed his graduation in Civil Engineering in 1992, and Post-Graduation and Doctorate in Structural Engineering. She is working with Birla Vishvakarma Mahavidyalaya, Department of Structural engineering in as Associate Professor. She has been teaching since last 18 years. She in instrumental in fetching 2 grants worth Rs. 14.0 lcs under AICTE MODROB and R & D grant. Apart from academics, she is involved in consultancy activities for Research and Testing work in the Department. She has 34 research papers to her credit. She has guided 03 PhD scholars and 14 master level, and 01 UG projects. She registered PhD guide for S.P. University (SPU) and Gujarat Technical University (GTU) and has been performing examiner duties for above universities. She is a life member of Indian Society for Technical Education (ISTE) and the Institute of Engineers (India)