International Journal of Innovative Research in Engineering & Management (IJIREM)
ISSN: 2350-0557, Volume-3, Special Issue-1, April-2015
Fifth National Conference on Innovative Practice in Construction Waste Management (IPCWM'15) On 8th & 9th April, 2015
Organized by Department of CIVIL Engineering, Sri Ramakrishna Institute of Technology, Coimbatore, India

Experimental Research on Eco-Friendly Concrete by Using C&D Waste as Aggregates

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ABSTRACT
A major problem faced by the construction industries nowadays are the management and the disposal of construction & demolition waste. Therefore the recycling of Construction and Demolition Wastes has long been accepted to have the possibility of conserving natural resources. In some European countries it is used for both construction and maintenance, particularly where there is a scarcity of natural aggregate. Since the overall performance of recycled aggregates is lower than the natural aggregates, its application is limited. In order to improve the surface quality of recycled aggregates, they are washed with water and diluted acid. Strength properties of the treated and untreated coarse aggregate were compared. The results indicated that the compressive, flexure and split tensile strength of recycle aggregate is found to be less than the natural aggregate.

Keywords
Construction and Demolition Wastes, Recycled aggregates, Acid.

1. INTRODUCTION
The waste which is generated during the construction, remodeling and demolition process is known as construction and demolition waste. Normally the wastes are generated during the construction & demolition of buildings, bridges, dams, roads, flyovers etc., It mainly consists of concrete, tiles, timbers, plastics, metals such as steel, iron and aluminium. These wastes are highly denser and consume more space for their storage and disposal. In addition to this the wastes consists of considerable amount of toxic materials. These toxic materials are inert and are non-biodegradable which when disposed on open site; it causes harmful environmental health problems in addition to the traffic congestion. The recycling of Construction and Demolition Wastes has long been found to have the potential to preserve natural resources from being exploited rapidly. In some countries it is a standard alternative for both construction and maintenance, particularly where there is a shortage of construction aggregate. The benefits and weaknesses of using recycled aggregate in concrete have been broadly studied. The use of recycled aggregate 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. The undesirable effects of recycled aggregate on concrete quality limit the use of this material in structural concrete. So they can be used to make the pavement blocks, kerb stones, level the surface and for the filling purpose during the construction of pavements. However, the weaknesses of using recycled aggregate can be mitigated by incorporating a certain amount of fly ash into the concrete mixture since fly ash is known to be able reducer of creep and drying shrinkage of concrete.

2. C & D waste generation
The C & D wastes are generated normally from two major sources. They are large scale generators and small scale generators. The large scale generation is due to the construction & demolition of large structure like bridges, dams, flyovers, sky scrapers, huge precast structures etc., whereas the small scale includes the residential buildings, flats, commercial buildings and small scale industries.

3. Types of C & D waste
The types of construction & demolition waste obtain from a building structure depends upon the materials used for its construction. Generally the materials used in the construction process are classified into major components and minor components. Some of the major components are Concrete, Bricks, Cement plaster; Steel, Stone, Timber/ wood etc, the minor components are Conduits, Pipes, and Electrical fixtures, Panels, Glazed tiles & glass panels.

4. Storage of C & D waste
The construction & demolition waste generated in a site are to be stored in a place suitable for the collection and transportation of it. It should be stored in such a way that it reduces the risk of loading and unloading by the trucks during collection and disposal of the wastes. Normally the C & D wastes are dumped in a place without segregating the different materials into separate heaps. If it is done in this storage process it would facilitate the collecting group of individuals for further processing. In this primary stage, if the manpower is utilized in a proper manner it will help in the efficient reduction of the C & D wasted to be disposed.

5. Collection of C & D waste
The collection of C & D waste is an important phase. In this process the wastes are to be collected separately to make it easier for reusing or further recycling. Separate collecting boxes are kept in the site and the corresponding wastes are dumped in their respective boxes and the debris is to be collected separately. If this debris is collected in skips it can be lifted using hoist and transported either by trucks or by tractors. Front-end loaders with

sturdy trucks can be used for the collection of wastes from the large waste generation sites.

6. PROCESSING OF C& D WASTE

The collected C & D wastes are separately dumped into several heaps, if it is not done earlier. The processing of C & D wastes involves 3R concept (Reduce, Reuse and Recycle).

6.1 Reduce

It denotes the reduction of usage of the materials which cannot be reused or recycle after its utilization at once for construction. This is done at the planning stage for selection of materials for construction. In order to achieve this, the one who is responsible for planning the materials has to know clearly about the materials intended to be used in a construction process. Also, it means the reduction of risks in the future alteration and re-modeling works

6.2 Reuse

This is next to reducing phase. In this stage, due to some inevitable reasons we use some materials for the construction process. These materials should have reusable value and it mainly saves the expenditure in the new or renovation works to be undertaken. Some materials like steel and iron fabricated structures are uneconomical to recycle. So they can be reused in the structures either as it is or by modifying their dimensions. This is achieved by properly demolishing the structures with care. Also in addition to this if the doors, windows and other panel dimensions are kept constant during construction it gains more reusing values

6.3 Recycle

This is the most important phase of all the three. In this, if the materials used in construction are not reusable then they can be recycled. About 50 percent of materials used for construction are recyclable and can be separated from the debris to make it possible to use in construction again. All we need is little care in handling the wastes during the reusing and recycling process. Aluminium is the best recyclable metal used normally in fabrication of door/window panels which has infinite recycling capacity. But the fact is that, the amount for recycling a material should not out cost the purchasing of a same new material

7. 4M CONCEPTS

For any of the construction related works the 4M (Material, Machinery, Man power and Money) concept can be followed for the successful & economic completion of a project.

7.1 Material

Maintenance of the materials is very essential in a new construction or any other alteration works. Also in the demolition works the waste materials are to be maintained properly by collecting and dumping them for further reusing or recycling processes. If the demolished materials are not maintained properly with care they lose the reusable property and would cost much for recycling them for future use.

7.2 Machinery

Machinery includes all the machines and instruments involved in the demolition, collection, dumping, transporting, recycling etc,. These machineries are to be maintained properly for the efficient processing of the C & D waste recycling works. This leads to the uninterrupted processing of the C & D waste in a treatment plant.

7.3 Man power

The man power is utilized mainly at the preliminary stage for collection of the C & D wastes from a site. All the valuable and reusable things are obtained by separating the wastes manually. They are collected separately and dumped in a place into different heaps. Optimal utilization of man power is required to achieve the recycling process without much risk in the segregation process of the wastes.

7.4 Money

Although the process is completed successfully it should also be economic. So from that point of view, the concepts and the methods used in the overall process of the C & D waste recycling should be economic. Because while planning for any kind of work the amount to be spent for the process is compared with the beneficiaries and then only it is suggested for the consideration for further implementation of the process

8. Survey of EDA

For BIS specifications the durability standards are found to be in good agreement. As per European Environmental Commission (EEC) the C & D waste concrete are increased from 55 Million tons in 1980 to 302 Million tons by the year 2020 by EEC member countries. Special and strict rules & regulations were made in several countries like U.K, Holland and Japan

Country	No. of. recycling plants
Belgium	60
France	50
Netherland	70
London	120
Germany	220
Denmark	20
Italy	43

9. International Status

Initiatively the work was started in 1945. The first effort was made by Nixon in 1977. Later Hansen and others also involved in this regard in 1992. European Union produces 180 Million tons of C & D waste. EU says that about 500kg of C & D wastes are corresponding to each citizen. 78000 tons of RCA is used in Holland in 1994. Netherland produces about 14 Million tons of buildings of C& D waste per annum in which 8 Million tons are recycled for use in unbound road base courses.

10. Indian Status

25% of 48 Million tons of C & D waste per annum has been recycled as per CPCB. As per TIPAC the construction industry has been producing 12-14.7 Million tons per annum out of which 7-8 Million tons are concrete and brick waste. SERC Ghaziabad has taken pilot R & D project.

11. General tips for C & D waste management

Concrete structures should be demolished with care why because good sized precast elements are also obtained. Demolishing the

structure within minutes affects the valuable reusable precast elements obtained from the structure.

If it is impossible to obtain a precast element from the C & D waste, the demolished concrete waste can be crushed further and sent to recycling plant. In this plant, the crushed wastes are further surface treated and the Recycled Concrete Aggregates (RCA) is obtained. Depending upon the quality and strength characteristics the aggregates are classified into High, Medium and Low grades. Depending upon our requirements, the respective grade of aggregates can be used for construction. Bricks are next to concrete in volume in a C & D waste sample. The bricks have very good thermal properties but have greater shrinkage. The bricks are durable and can be reused in the structures if it is demolished with care and the cement plasters over its surface are removed.

If the bricks are broken, they can be used as brick bats in the formation of surkhi. Also the broken bricks can be used for side filling of the foundation at sites effectively.

Tiles are also used in the construction widely for various purposes. These tiles are difficult to recover as it is because they are fitted with cement paste tightly with wall. If they are broken into pieces, they can be used to make decorative wall surfaces.

The crushed tiles can be used as fine aggregates in concrete. The crushed tiles have the similar properties of the conventional sand as fine aggregate.

Timbers are mostly reused as it is because of their high rates for the purchase of new timbers. This can be achieved by using the doors/window panels of standard sizes. If the timbers are more damaged and if it is not fit for reusing, it can be chipped or shredded.

The chipped or shredded wood are used for various purpose such as making paper by paper industries and for bulking the sewage sludge, etc,.

Steel and aluminium are the two major wastes obtained during the demolition of a building. The steel structures can be reused as it is. Because reusing save the cost for melting the steel and rolling it into a new steel beam.

Aluminium is infinitely reusable metal. The can be reused as solid bonding material. They can also be melted in the foundry to make new materials for using them again efficiently.

Plastic scraps and wastes recovered from the demolition site is reprocessed and transformed into different useful things. Plastics are not recycled into the same type of plastics. The recycled plastics are not often recyclable. High density polyethylene is a recycled plastic which is used to make road side kerbs, plastic lumbers, benches, tables, cargo truck liners, etc,.

12. EXPERIMENTAL PROGRAM

12.1 Research Scope

To study the strength properties of concrete made with recycled aggregate after incorporating water washing and presoaking treatments using nitric, hydrochloric and Sulphuric acid.

12.2 Materials Used

12.2.1 Cement

The Portland Pozzolana Cement was used for the preparation of test specimens.

12.2.2 Fine aggregate

The fine aggregate used in this experimental investigation was natural river sand confirming to zone II.

12.2.3 Natural Coarse aggregate

Crushed granite aggregates particles passing through 20mm and retained on 4.75mm I.S sieve was used as natural aggregates which met the grading requirement.

12.2.4 Recycled Coarse aggregate

Crushed concrete aggregate waste passing through 20mm and retained on 4.75mm I.S sieve were used as recycled coarse aggregate and they met the grading requirements.

12.2.5 Water

Portable water available in laboratory was used for mixing and curing the concrete specimens.

13. Pre Soaking Treatments

The recycled aggregates were crushed and soaked in water for 24 hours for water treatment then kept for drying. Similarly the recycled aggregate soaked with diluted sulphuric, hydrochloric and nitric acids separately and then those aggregates were used for casting of concrete cubes, prisms and cylinders.

14. Acid properties

The acid which was bought was highly concentrated so 0.1ml of concentrated acid was mixed with 150 ml of water and diluted the laboratory under expert supervision.

15. Preparation of Recycled Aggregates

15.1 Natural Aggregates (NA)

The natural Aggregate is obtained from the natural resources such as stone quarries which are expensive in nature. So in order to achieve economical concrete we need to replace the NA by various treated recycled aggregates which have been enumerated as follows.

15.2 Recycled Aggregates (RA)

The recycled aggregates are obtained from the demolished sites they are not subjected to any treatment except surface cleaning. And make use of the sieving process the aggregate size distribution can be evolved.

15.3 Recycled Aggregates treated with water (R.Water)

The recycled aggregates obtained from the demolished sites are treated with ordinary portable water for about 24 hours. Then they are taken out and the surface is allowed to dry.

15.4 Recycled Aggregates treated with Nitric acid (R. HNO_3)

The recycled aggregates are treated with diluted Nitric acid (HNO_3) having 0.1 normality for about 24 hours in a separate glass containers.

15.5 Recycled Aggregates treated with Sulphuric acid (R. H_2SO_4)

The recycled aggregates are treated with diluted Sulphuric acid (H_2SO_4) having 0.1 normality for about 24 hours in a separate glass containers.

15.6 Recycled Aggregates treated with Hydrochloric acid (R. HCl)

The recycled aggregates are treated with diluted Hydrochloric acid (HCl) having 0.1 normality for about 24 hours in a separate glass containers.

16. RESULTS & DISCUSSIONS

It is observed from the Chart 1. Compared to natural aggregate concrete the compressive strength of recycled aggregate was decreased by 24.53%. The recycled aggregate treated with water has increased 11.11%, nitric acid by 21.57%, sulphuric acid increased by 14.89% and hydrochloric acid increased by 4.76% than the recycled aggregate.

Chart 2.shows that the split tensile strength of recycled aggregate was decreased by 9.55% than the natural aggregate. The strength of water treated recycled aggregate was increased 3.15%, strength of nitric acid treated recycled aggregate is increased by 5.38% , sulphuric acid treated recycled aggregate increased by 3.52%, and hydrochloric acid treated recycled aggregate increased by 3.91% than the recycled aggregate.

It can be seen from the Chart 3. the flexural strength of recycled aggregate was decreased by 17.39% compared to natural aggregate, and the strength of water treated recycled aggregate was increased by1.72%, the strength of nitric acid treated recycled aggregate increased by 8.10%,sulphuric acid treated recycled aggregate increased by 3.39% and hydrochloric acid treated recycled aggregate increased by 3.39% than the recycled aggregate.

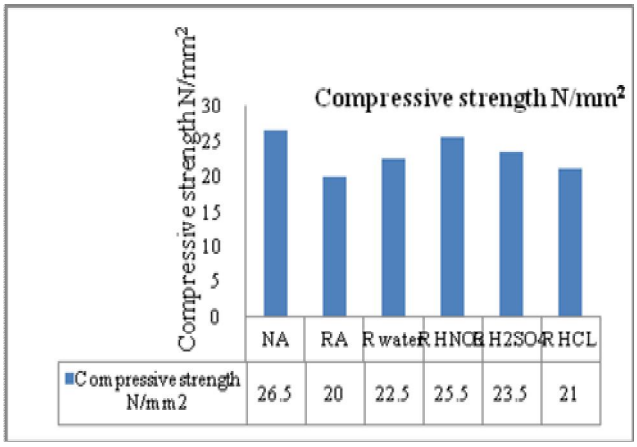

Chart 1. Compressive strength

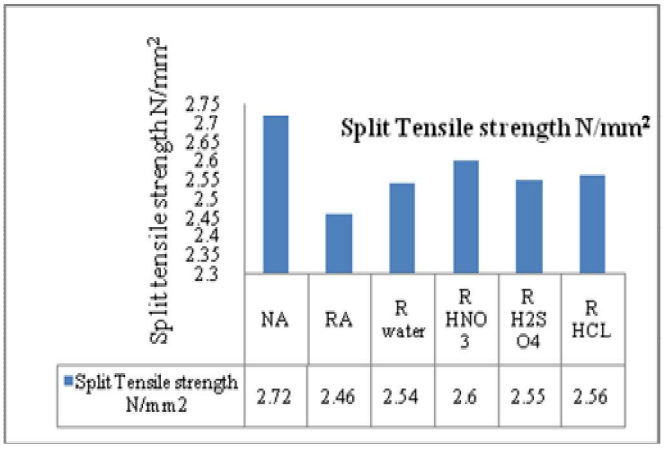

Chart2. Split tensile strength

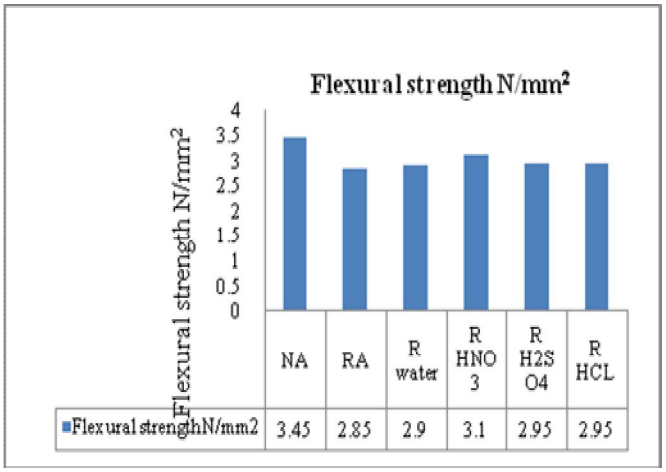

Chart 3. Flexural strength

17. CONCLUSION

Based on the results obtained from the experiment the following conclusions are drawn. The test results showed that the flexural, compressive and split tensile strength of the recycled aggregate concrete is found to be lower than the natural aggregate. However the strength of recycled aggregate concrete can be improved by the water and acid treatments. Furthermore Recycled aggregate treated with nitric acid displayed the expected result compared to the hydrochloric and sulphuric acid and from economical point of view; water and acid treated recycled aggregates can be used in place of natural aggregates for temporary structures.

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