

Sustainability of Recycled Aggregate – A Futuristic Prospect

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Abstract - In order to serve and giving a height to humanity, we are continuously producing metric tons of concrete on daily basis. On the other hand, we continuously generate concrete aggregates from the demolished structures which poses a great worry about their dumping. So, we are fighting on two sides: 1.) to complete the rising demand of construction work & 2.) to dump the daily produced concrete aggregates from the C&D sites. Thus, use of recycled aggregate provides a magical solution of above discussed problems. RCA is a material for future use. Several countries from Europe, Asia, America & Africa are continuously using RCA as a substitute for NA, & for this purpose they are relaxing their code of practices. In this paper, we will discuss the various features of RCA & its components like basic properties of recycled FA and recycled CA & also compares these properties with NA. Some important properties like texture, water absorption capacity of recycled CA, compressive strength, flexural strength, workability etc. of produced concrete are examined here for different combinations of recycled aggregate with NA. In order to increase the capacity, we will see the behavior of fly ash (both partial replacement & addition). Also, we see a great need for adopting a code of practice in India on the structural behavior of RCA.

Key Words: Recycled concrete aggregates (RCA), Natural aggregates (NA), Coarse aggregate (CA), Fine aggregate (FA) & Construction & Demolition (C & D)

1. INTRODUCTION

Concrete is the second largest commodity to be consumed in the world. But in the world of construction industry concrete is the main construction material without which no one can imagine the fulfillment of construction requirement. Present growth rate of India is about 8%. To compete with this high growth rate, fast infrastructural development is needed, require a large quantity of construction commodity. Concrete is the backbone for any construction work. Since aggregates demand 70-75% of concrete components, we need such a high demand of materials.

On the other hand, our natural resources are decreasing fastly, so a huge problem is coming in front of completion of demand. The scholars & the researchers from all over the world are investigating the way for the solution. A form of

the solutions of this problem is in the use of aggregates obtained from construction & demolition sites. This process includes the recycling of generated aggregates followed by crushing into requiring sizes and shapes & take off the unwanted compounds from the outer surfaces of the aggregates. Thus, obtained aggregates are known as recycled concrete aggregates.

A report of "THE HINDU", a renowned newspaper, of month of March 2007, India produces about 23.75 MT demolition waste annually as a side product. As per report of Central Pollution Control Board, (Delhi) 48 MT solid wastes was produced in year 2014 out of which 14.5 MT wastes was produced from construction sector, out of which embankment use was only 3%. Thus, management of C & D waste is a problem due to generation of huge quantity of demolition rubble, increasing shortage of dumping sites, rise in cost of disposal & greater of all is the environmental degradation.

Also, from economic point of view, cost of produced recycled aggregates is very less (20-25% of natural aggregates), thus saves a huge amount of resources being expended in the construction works. Also, it prevents time & labor thus provide an economic foundation for its use. From environmental point of view, about 0.0046 metric tons of C_x is produced during production of 1 ton of natural aggregates but only 0.0024 metric tons of C_x is produced during same amount of recycled aggregates. Keeping in view, the global consumption of $10 * 10^9$ tons per year of aggregates for concrete, the carbon footprint can be easily estimated.

1.1 Research works in different Countries

- Scotland- About 67% materials were recycled in 2010, rest 33% material were being disposed of in landfill & other sites. The government is trying to modify codal provisions.
- Denmark- In 2003 Danish Environmental Protection Agency (DEPA) stated that 30% of the total waste was related to C&D work. Around 70-75% waste is generated from demolition activity while 20-25% was from renovation & remaining from new construction works. Due to limitations of landfill sites, recycling is the primary need for the country.

- Netherland- Out of total C&D waste being generated, 80% is from brick & concrete. Several steps have been taken since 1993 like prevention of waste, stimulate recycling, promotion of building materials to achieve longer life etc. [32].
- USA- There is a large emphasis on sustainable developments. Here green building concept is used by promoting 'deconstruction' in place of 'demolition'. That why here C&D waste is very small (around 22% only).
- Japan- This is an earthquake prone country so here main emphasis is on developing quake resistant material from C&D waste [32].
- Singapore- Here C&D waste is separately collected from sites & recycled. Here companies are built to deal 3MT per year capacity.
- Hong Kong- Here concrete bricks & paving blocks have been successfully produced by impregnation of photo- catalyst for controlling nitrogen compounds from the air.



Fig 1. Tiles are made from C&D waste

1.2 Indian Prospects on RCA

Since in the Indian scenario, the natural resources contributing to construction work are depleted fastly at such a high rate so that it is estimated that if no further alternatives are searched out, then in next 30 years they will be depleted completely. On the other hand, there are huge no. of demolition work of pre- existed old structures are also on the same pace. The waste obtained from demolition work present a giant problem in front of civilization. If no better choices regarding their disposal are searched then they will grasp the precious land which is already limited & unable to take any such further load.

To visualize both the above problems, there is a better choice to use recycled aggregate as it can solve both the problems: - I) provide a better alternative to substitute for NA in construction work, II) to solve disposal problem of demolition waste as it can be further used in construction work after recycling.

In India, there is no any solid provision in this way yet. There is a lack of works in this field. Since there is no proper channel & scientific research towards this work, so there is a lack of knowledge in this field. TIFAC conducted a survey & found that Indians are not aware of RCA use. It also stated that they are not even heard about any such type of work. Governmental laws & codal provisions are not available in this field. These things make the situation even worse than before.

On looking over such conditions, there is a great need to take a step in this field because the provision of RCA will be a better choice in future infrastructural need. Also, several lands become choked, due to heavy waste loads spread over them.

2. METHODOLOGY

RCA are mainly obtained from the crushing of concrete pavement and massive structures including buildings. The main reason for choosing the structural building as the source for recycled aggregate is because they give a huge amount & constituent – varying demolition waste. The recycling process involves breaking, removing, crushing, stockpiling & making concrete blocks for testing. The source of concrete will be mixed with other materials. The obtained aggregates are sieved according to IS 23186 (part V)-1963 and IS: 383- 1970 as per our need. With the help of these materials, sand, water & admixtures are mixed in proportions to make test blocks confirming to IS 10262: 2009 and IS 456: 2000. Various tests are carried out & their results are compared with NA. Flyash is also mixed in two ways: i) as a partial replacement by weight of cement & ii) as an addition by weight of cement. Both effect of Fly ash on fresh Concrete made of RCA & effect of Fly ash on hardened Concrete made of RCA are examined.



Fig.2 Recycled Concrete Aggregate

3. TEST RESULTS OF RCA

The significant findings of the tests carried out are

- 1) Shape & texture-: Both coarse & fine aggregates turn into very angular & rough caused by the effect

of crushing & also due to sticky cement particles on the surfaces of aggregates.

- 2) Water absorption capacity:- Due to cling cement particles on the outer surface of aggregates, water absorption capacity of RCA becomes twice as compared to water absorption capacity of concrete made with natural aggregates. This is so because adhered cement particles has more tendency to absorb water and also to retain it.
- 3) Specific gravity:- Sp. gr. of recycled aggregates was found between 2.54 to 2.62 which are less as compared to NA. The lower sp. gr. is due to the lower denseness of recycled aggregate. This is so because of crushed mortar present whose nature is porous & has some air entrained.
- 4) Bulk density:- Bulk density is lower upto 12.5% to 14% as compared to natural aggregate.
- 5) Crushing & Impact values:- Recycled aggregate is relatively weaker in both crushing values & impact values as compared to natural aggregate. With the help of crushing & impact test, it is estimated that recycled aggregate can be used beneficially for applications in addition to wearing courses in roads.
- 6) Compression strength:- Compression strength result around 70-80% as compared to natural aggregate. Hence it can provide a satisfactory option for use in structural applications.
- 7) Slump value & slump loss :- From the slump tests, for a given w/c ratio, the concrete made from RCA shows a higher slump, level of workability and plasticity than a similar concrete made with NA.

TABLE I Comparisons between NA & RCA

Properties	Natural Aggregates	Recycled Concrete Aggregates
Shape & texture	Well rounded, smooth to angular & rough	Angular & rough surface
Water absorption	1% - 2%	2% - 6.5%
Specific gravity	2.7 - 2.8	2.54 - 2.6
Loss abrasion test mass loss	15% - 30%	20% - 45%
Slump value	65 mm	81 mm

4. CONCLUSIONS

From the slump tests, for a given w/c ratio, the concrete made from RCA shows a higher slump, level of workability and plasticity than a similar concrete made with NA. It is higher sensitive to the w/c ratio from freshly mixed concrete made with RCA, and, consequently, to the quantity of water. This suggests that concrete made from RCA needs more water content than similar concrete made from NA, since

RCA absorb more water as compared to NA. Inclusion of fly ash increases workability & slump height.

From the compression tests at different ages of curing, it is observed that the compressive strength as a function of the concrete age resulted in weaker hardened concrete made with RCA as compared to NA. The difference in compressive strength between both concretes decreased with the age. From the compressive strength versus water cement ratio results, the compressive strength of concrete made with RCA was always weaker than that of concrete made with NA.

From the above data, we can see that compressive strength obtained from fly ash as 25 % partial replacement is tolerable according to IS codes, but fly ash as 30 % partial replacement is very less & hence can't be tolerated.

Decreased w/c ratio causes an increment in compressive strength in concrete made with RCA.

An addition of fly ash as admixture of cement causes a gain of compressive strength of concrete made with RCA. This increase in strength increases with increment of fly ash content.

From the above data, it can be easily understood that concrete made with 100 % RCA with addition of fly ash up to 25 % or more is equal to compressive strength of concrete made with 100 % natural aggregate. Thus, we can easily replace use of natural aggregate by addition of fly ash in RCA to obtain same strength in future.

Same phenomena occurred in case of tensile strength case. Inclusion of fly ash as partial replacement causes reduction in tensile strength. This reduction increases with increase of fly ash content as partial replacement. On the other hand, inclusion of fly ash as admixture increases the tensile strength. This increment increases with increase of fly ash content.

In case of use of fly ash as partial replacement, it is observed that 25% replacement is tolerable but its further amount can't be accepted.

Hence, we can say that partial replacement of fly ash up to 25% is recommended in point of view of compressive strength & tensile strength.

5. FUTURE RECOMMENDATIONS

From current & past studies & tests, it is strongly advised

- 1) To make codes of practices for use of RCA in no. of construction activities
- 2) To increase the awareness & promote the uses of RCA

- 3) Nationwide research should be done to take more advantages of RCA
- 4) Research must be done on different types of structures made with RCA
- 5) Test must be carried on RCA behavior with silica flumes and other such strength providing substances

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