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Use of Recycled Concrete Aggregate for Road Construction

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***Abstract*: When structures made of concrete are demolished, concrete recycling is an increasingly common method of utilizing the rubble. Concrete was routinely trucked to landfills for disposal, but recycling has a number of benefits that have made it a more attractive option in this age of great environmental awareness, more environmental laws, and the desire to keep construction cost down. After demolition of old construction, the removed concrete is often considered worthless and disposed of as demolition waste. By collecting such concrete, cleaning of crushed concrete and breaking it to smaller pieces to manufacture aggregate which is known as recycled aggregate. Recycled aggregates are the materials for the future. Concrete aggregate collected from demolition sites is put through a crushing machine. Crushing facilities accept only uncontaminated concrete free from trash, wood, paper and other foreign materials. The application of recycled aggregate has been started in a large number of construction projects of many European, American, Russian and Asian countries. Many countries are giving infrastructural laws relaxation for increasing the use of recycled aggregate. In this paper the properties of crushed aggregate are determined by laboratory testing and their effects on road construction are studied. Basic concrete properties like crushing strength, impact value, Los Angles abrasion test etc. are conducted for different combinations of recycled aggregate with natural aggregate. After verifying different properties of crushed aggregate with standard value recommended by IS code, this recycled concrete aggregate is used as substitute material for raod construction.**

***Keywords*: Demolition, Recycling, crushing, uncontamination**

1. Introduction

A. Overview

When structures made of concrete are demolished, concrete recycling is an increasingly common method of utilizing the rubble. Concrete was once routinely trucked to landfills for disposal, but recycling has a number of benefits that have made it a more attractive option in this age of great environmental awareness, more environmental laws, and the desire to keep construction cost down. Concrete aggregate collected from demolition sites is put through a crushing machine. Crushing facilities accept only uncontaminated concrete, which must be free of trash, wood, paper and other such materials. Metals such as rebar are accepted, since they can be removed with magnets and other sorting devices and melted down for recycling elsewhere. The remaining aggregate chunks are sorted by size. Larger chunks may go through the crusher again. After crushing has take place, other particulates are filtered out through a variety of methods including handpicking and water flotation. Crushing at the actual construction site using portable crushers reduces construction costs and the pollution generated when compared with transporting material to and from a quarry. Large road-portable plants can crush concrete and asphalt rubble at 600 tons per hour or more. These systems normally consist of a rubble crusher, side discharge conveyor, screening plant, and a return conveyor from the screen to the crusher inlet for reprocessing oversize materials. Compact, self-contained mini-crushers are also available that can handle up to 150 tons per hour and fit into tighter areas. With the advent of crusher attachments those connected to various construction equipment, such as excavators - the trend towards recycling on-site with smaller volumes of material is growing rapidly. These attachments encompass volumes of 100 tons/hour and less.

Smaller pieces of concrete are used as gravel for new construction projects. Sub-base gravel is laid down as the lowest layer in a road, with fresh concrete or asphalt poured over it. The US Federal Highway Administration may use techniques such as these to build new highways from the materials of old highways. Crushed recycled concrete can also be used as the dry aggregate for brand new concrete if it is free of contaminants. Also, concrete pavements can be broken in place and used as a base layer for an asphalt pavement through a process called rubblization. Larger pieces of crushed concrete can be used as riprap revetments, which are a very effective and popular method of controlling stream bank erosion. With proper quality control at the crushing facility, well graded and aesthetically pleasing materials can be provided as a substitute for landscaping stone or mulch.

B. Concept

After demolition of old construction, the removed concrete is often considered worthless and disposed of as demolition waste. By collecting such concrete and breaking it up, recycled concrete aggregate (RCA) is created. Crushed concrete aggregates also called as recycled concrete aggregates are fragments and pieces of concrete which are demolished or rebuild. These crushed concrete are cleaned from dirt and broken to smaller pieces to manufacture aggregate which is

termed as recycled concrete aggregate.

C. Necessity

- There are various reasons that encourages the use of crushed concrete which include:
- It provides a low-cost alternate solution to crushing natural raw materials.
- Crushed concrete aggregate makes projects sustainable by reducing depletion of natural aggregate.
- Concrete produced with crushed concrete aggregate has smaller carbon footprint.
- Conserve natural resources by reducing the need for gravel mining, water, coal, oil and gas.
- When used as the base material for roadways, reduces pollution from waste transport to LANDFILLS AND DUMPS.

2. Aim and objective of study

A. Aim

The aim of this research work is to study suitability of demolition concrete waste as artificial aggregate for road base construction work.

B. Objective

*T*o find different physical and mechanical properties of Recycled coarse aggregate concrete (RCA) like compressive strength, workability, impact value, crushing value, abrasion value etc.

- To compare physical and mechanical properties of Recycles coarse aggregate concrete (RCA) with Natural coarse aggregate concrete (NCA).
- To obtain desired properties of recycled coarse aggregate concrete so that it can be suitable to use in road construction.
- To reduce consumption of natural aggregate and depletion of natural aggregate by utilizing demolished concrete in rural road construction.

3. Literature review

Selected international experience has been outlined here which has relevance for the Indian situation:

A) Scotland – About 63% material has been recycled in 2000, remaining 37% material being disposed in landfill and exempt sites. a) The Government is working out on specifications of recycling and code of practice. b) Attempts are being made for establishing links with the planning system, computerizing transfer note system to facilitate data analysis and facilitating dialogue between agencies for adoption of secondary aggregates by consultants and contractors.

B) Denmark – According to the Danish Environmental Protection Agency (DEPA), in 2003, 30% of the total waste generated was Construction & Demolition waste. a) According to DEPA around 70-75% waste is generated from demolition activity, 20-25% from renovation and the remaining 5-10% from new building developments. b) Because of constraints of landfill site, recycling is a key issue for the country. c) Statutory orders, action plan and voluntary agreements have been carried out, e.g., reuse of asphalt (1985), sorting of Construction & Demolition waste (1995) etc.

C) Netherlands – More than 40 million Construction & Demolition waste is being generated out of which 80% is brick and concrete. a) A number of initiatives taken about recycling material since 1993, such as prevention of waste, stimulate recycling, promoting building materials which have a longer life, products which can be easily disassembled, separation at source and prohibition of Construction & Demolition waste at landfills.

D) USA – Construction & Demolition waste accounts for about 22% of the total waste generated in the USA. a) Reuse and recycling of Construction & Demolition waste is one component of larger holistic practices called sustainable or green building practice. b) Green building construction practices may include salvaging dimensional number, using reclaimed aggregates from crushed concrete, grinding drywall scraps, to use as soil amendment at the site. c) Promoting „„deconstruction"" in place of „demolition". d) Deconstruction means planned breaking of a building with reuse being the main motive.

E) Japan – Much of the R&D in Japan is focused on materials which can withstand earthquake and prefabrication a) 85 million tons of Construction & Demolition waste has been generated in 2000, out of which 95% of concrete is crushed and reused as road bed and backfilling material, 98% of asphalt + concrete and 35% sludge is recycled.

F) Singapore – Construction & Demolition waste is separately collected and recycled. A private company has built an automated facility with 3, 00,000 ton per annum capacity.

G) Hong Kong – Concrete bricks and paving blocks have been successfully produced impregnation of photo catalyst for controlling Nox in ambient air.

H) India – Use for embankment purpose in bridges, roads etc. up to 3% to 4% of total production. Akmal, Sami1 (2011) insist that the available resources should be used appropriately & whenever recycled it should be done at the national level with the help of Gulf Cooperation Council (GCC) & Environment Protection Industrial Co (EPIC). They observe that GCC countries produce more than 120 million tons of waste every year out of which 18.5% is related to solid construction waste. Results from Dubai municipality indicate that out of 75% of 10,000 tons of general waste produced, 70% is of concrete demolition waste.

4. Advantages and disadvantages

A. Advantages

- Used for construction of precast & cast in situ gutters & kerb's.
- Cost saving - There are no detrimental effects on concrete

& it is expected that the increase in the cost of cement could be offset by the lower cost of Recycled Concrete Aggregate (RCA).

- 20% cement replaced by fly ash is found to control alkali silica reaction (ASR).
- Save environment: There is no excavation of natural resources & less transportation. Also less land is resave time: There is no waiting for material availability.
- Less emission of carbon due to less crushing.
- Up to 20% replacement of natural aggregate with RCA or recycled mixed aggregates (RMA) without a need for additional testing for all concrete up to a characteristic strength of 65 MPa.

B. Disadvantages

- Less quality (e.g. compressive strength reduces by 10-30%).
- Duration of procurement of materials may affect life cycle of project.
- Land, special equipment's machineries are required (more cost).
- Very high water absorption (up to 6%).
- It has higher drying shrinkage & creep.

5. Research Methodology

Demolished concrete both plain cement concrete & reinforced cement concrete is collected from various sites located in the vicinity of Kolhapur and Ichalkaranji city respectively. This collected material is crushed by hammer to separate the aggregates & reduce their sizes in smaller fraction. Any foreign objectionable material found get removed manually and mechanically. On these separated concrete aggregates various testes are conducted in laboratory as per Indian Standard code. the test to be conducted on concrete aggregate are crushing test, abrasion test, impact value test, compressive strength test etc. after testing part, analysis of these concrete specimen is done and results are compared with natural aggregates. After that these concrete aggregate is suitably used as aggregate for road base construction. Recycled aggregate reduces the impact of waste on environment. By using some percentage in construction sector, cost is saved, due to reduction of transportation & manufacturing process.

6. Test conducted on recycled aggregate

A. Crushing and Impact Values

The recycled aggregate is relatively weaker than the natural aggregate against different mechanical actions. As per IS 2386 part (IV), the crushing and impact values for concrete wearing surfaces should not exceed 30% & for other than wearing surfaces 45% respectively. The crushing & impact values of recycled aggregate satisfy the BIS specifications limit. From crushing & impact test it is found that use of recycled aggregate is possible for application other than wearing surfaces.

B. Compressive test on cubes

The average compressive strengths of cubes cast are determined as per IS 516 using RCA and natural aggregate at the age 3, 7, & 28days. As expected, the compressive strength of RAC is slightly lower than the conventional concrete made from similar mix proportions. The reduction in strength of RAC as compare to NAC is in order of 8-14% and 10-16%for M-30 & M-40 concretes respectively. The amount of reduction in strength depends on parameters such as grade of demolished concrete, replacement ratio, w/c ratio, processing of recycled aggregate etc. As per test results the strength of recycled aggregate cube is more than target strength, so RCA can be used for construction purpose.

7. Conclusion

1. Use of recycled aggregate up to 30% does not affect the functional requirements of the structure as per the findings of the test results.
2. Various tests conducted on recycled aggregates and results compared with natural aggregates are satisfactory as per IS 2386.
3. Due to use of recycled aggregate in construction, energy & cost of transportation of natural resources & excavation is significantly saved. This in turn directly reduces the impact of waste material on environment.

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