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Experimental Study of Recycled Aggregate Concrete with Partial Replacement of Cement by Fly Ash

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ABSTRACT: This paper consists of an overview over the development of recycling of concrete and the use of concrete with recycled materials. The trend of the utilization of recycled aggregates for the developing infrastructures is the solution to the problem of an excess of waste material, not forgetting the parallel trend of improvement of final product quality. The utilization of waste construction materials has to be related to the application of quality guarantee systems in order to achieve suitable product properties. Therefore the complete understanding of the characteristic of new materials becomes so important in order to point out its real possibilities. The studies on the use of recycled aggregates have been going on for 50 years. In fact, none of the results showed that recycled aggregates are unsuitable for structural use. Only having inadequate number of studies in durability aspects, made recycled aggregates to be preferred just as stuffing material for road construction. In the present study, an experimental investigation was conducted to study the properties of concrete, when the Natural Coarse Aggregate (NCA) is replaced with Recycled Coarse Aggregate (RCA). Specimens are prepared with natural, recycled coarse aggregates and to be tested after a curing periods of 7 and 28 days. The use of recycled aggregates in concrete opens a whole new range of possibilities in the reuse of materials in the building industry.

KEYWORDS: Recycled concrete, Fly ash, Recycling, Reuse

I.INTRODUCTION

Demolition of old and deteriorated buildings and traffic infrastructure, and their substitution with new ones, is a frequent phenomenon today in a large part of the world. The main reasons for this situation are changes of purpose, structural deterioration, rearrangement of a city, expansion of traffic directions and increasing traffic load, natural disasters (earthquake, fire and flood), etc. For example, about 850 millions tones of construction and demolition waste are generated in the EU per year, which represent 31% of the total waste generation [1]. In the USA, the construction waste produced from building demolition alone is estimated to be 123 million tons per year [2]. The most common method of managing this material has been through its disposal in landfills. In this way, huge deposits of construction waste are created, consequently becoming a special problem of human environment pollution. For this reason, in developed countries, laws have been brought into practice to restrict this waste: in the form of prohibitions or special taxes existing for creating waste areas. On the other hand, production and utilization of concrete is rapidly increasing, which results in increased consumption of natural aggregate as the largest concrete component. For example, two billion tons of aggregate are produced each year in the United States. Production is expected to increase to more than 2.5 billion tons per year by the year 2020 [3]. This situation leads to a question about the preservation of natural aggregates sources; many European countries have placed taxes on the use of virgin aggregates. A possible solution to these problems is to recycle demolished concrete and produce an alternative aggregate for structural concrete in this way. Recycled concrete aggregate (RCA) is generally produced by two-stage crushing of demolished concrete, and

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screening and removal of contaminants such as reinforcement, paper, wood, plastics and gypsum. Concrete made with such recycled concrete aggregate is called recycled aggregate concrete (RAC). The main purpose of this work is to determine the basic properties of RAC depending on the coarse recycled aggregate content, and to compare them to the properties of concrete made with natural aggregate (NAC)—control concrete [4].

Recycling of aggregate material from construction and demolition waste may reduce the demand – supply gap in both these sectors. While retrievable items such as bricks, wood, metal, tiles are recycled, the concrete and masonry waste, accounting for more than 50% of the waste from construction and demolition activities, are not being currently recycled in India. Recycling of concrete and masonry waste is, however, being done abroad in countries like U.K., USA, France, Denmark, Germany and Japan [5]. The successful recovery and recycling of construction waste should be conducted, in order to satisfy future expectations, without assuming unnecessary risks and using the adequate processes available.

The ideal process should be as follows “to construct for demolishing, to demolish for recycling, to recycle for constructing”. If this process was strictly complied with residues would not be a future problem as their dimensions would be controlled and limited [11].

II.FLY ASH

Fly ash is the waste obtain from burning of coal and the main source of fly ash is from thermal plant and steel plants etc., Improper disposal of fly ash will result in causing pollutions to the environment [7]. Fly ash compresses of minute particles which when mix with the atmosphere cause pollution problems. Fly ash can be used as a cement replacement material in concrete and the research work on this concluded mechanical properties of concrete increases with the fly ash in concrete as cement replacement material or admixtures [12], [18].

III.RECYCLED AGGREGATE (RA) CONCRETE

A thorough understanding of the basic engineering properties of 14/10 mm RC aggregate allows its full utilization and correct application as the coarse aggregate in concrete [15]. RA Concrete samples were prepared and used in the investigation of various properties including; compressive strength, volume of permeable voids, micro structural development, porosity, and sound absorption [9].

IV.OPPORTUNITIES FOR RECYCLING

In order to meet the challenges of recycling, it is necessary that all opportunities, barriers and obstacles are detected and considered [10]. The opportunities must be exploited, which can for example involve the recycling of concrete and masonry into aggregate, substituting natural materials:

- Aggregate bound in concrete
- Unbound sub-base and base materials

The opportunities for the production of concrete from recycled concrete are generally described in the ACI 555 report [6]. The recycling of concrete waste in a global perspective is described by Torben C. Hansen and Erik K. Lauritzen [8], Mats Topping [16] and Mats Topping and Erik K. Lauritzen [17]. The overcoming of these barriers and obstacles must be planned and carried out through a long-term action plan combined with adequate research and development. Implementation of the necessary legal, economic and technical instruments requires that initiatives involving legislation and regulations be taken.

V.BENEFITS OF RECYCLED AGGREGATE

The use of recycled aggregate can save money for local governments and other purchasers, create additional business opportunities, save energy when recycling is done on-site, conserve diminishing resources of virgin aggregates, and help local governments meet the diversion goals [13-14]. The experiments are conducted in series of test specimens with OPC, Fly Ash, and Recycled Coarse Aggregate as shown below:

- OPC + RCA
- OPC + RCA + Fly ash

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VI. TEST RESULTS

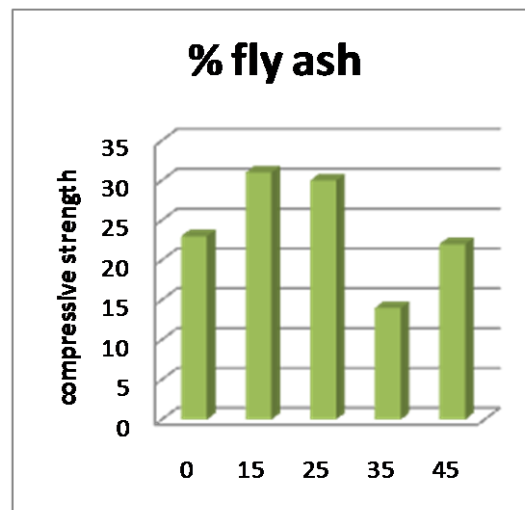
Compressive Strength of Cube

The specimens 100 x 100 x 100 mm were used to determine the compressive strength. Tests are carried out at the end of 7 and 28 days using Compressive Testing Machine of 2000 KN capacity. The test results are shown in Table - 1 and Table - 2.

Table – 1 Compressive Strength at 7 Days

Mix	% of RAC	% of Fly ash	Strength N/mm ²
M1	20	0	23
		15	31
		25	30
		35	14
		45	22
M2	40	0	20
		15	20
		25	18
		35	27
		45	23

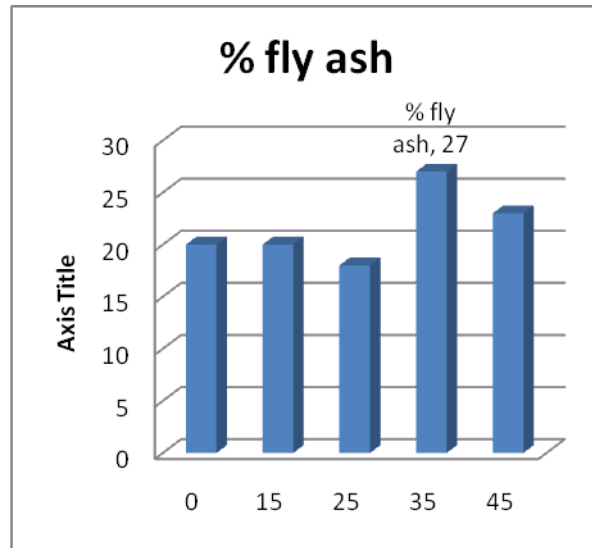
The test result of 7 days specimens were plotted as shown below:



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Graph 1 – Compressive Strength at 7 Days

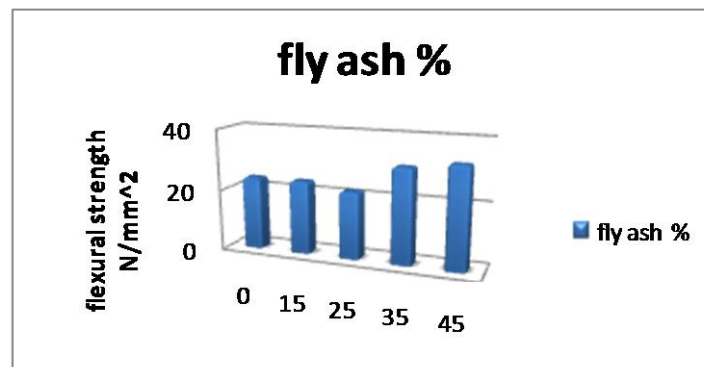
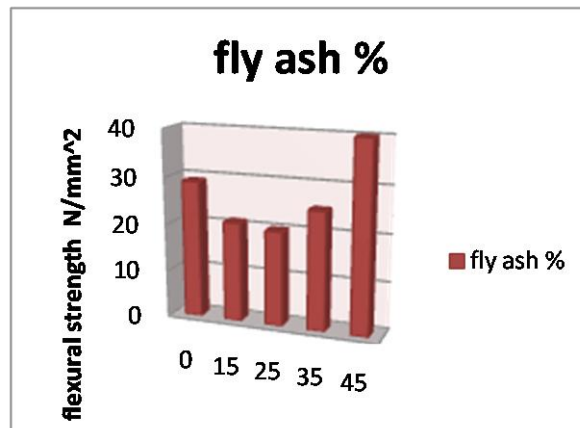
Table – 2 Compressive Strength at 28 Days

Mix	% of RAC	% of Fly ash	Strength N/mm ²
M1	20	0	29
		15	21
		25	20
		35	25
		45	40
M2	40	0	24
		15	24
		25	22
		35	31
		45	33

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Graph 2 – Compressive Strength at 28 Days

Flexural Strength

The beam specimens of size 100 x 100 x 500 mm were used to determine the Flexural strength. Test was carried out at the end of 28 days using Universal Testing Machine (UTM). The test results are shown in Table 3.

Table – 3 Flexural Strength at 28 Days

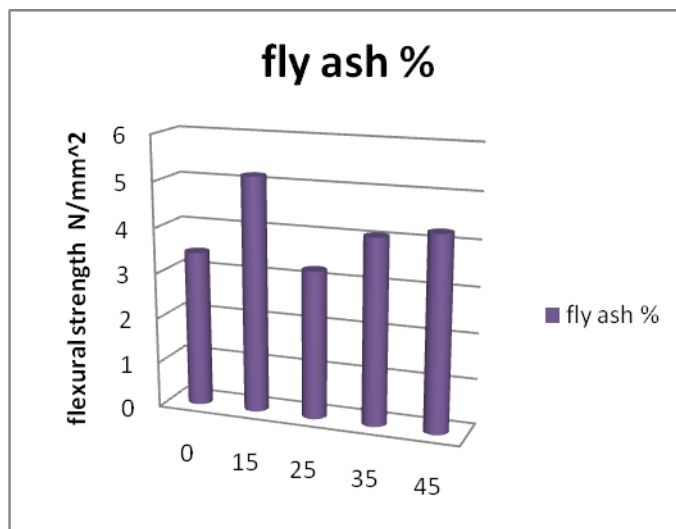
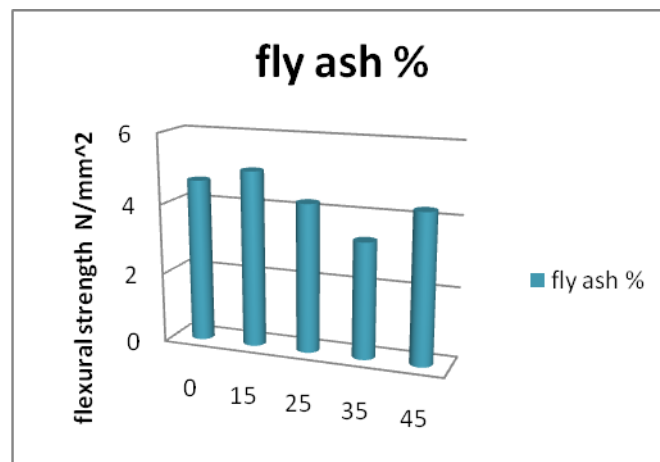
Mix	% of RAC	% of Fly ash	Strength N/mm ²
M1	20	0	4.65
		15	5.01
		25	4.23
		35	3.31
		45	4.26

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Mix	% of RAC	% of Fly ash	Strength N/mm ²
M2	40	0	3.43
		15	5.17
		25	3.25
		35	4.08
		45	5.26



Graph 3 – Flexural Strength at 28 Days

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VII.CONCLUSIONS

The investigation into RAC (Recycled Aggregate Concrete) concrete of Characteristic compressive strength of 20 MPa made from selected 20 mm RC (Recycled Concrete) aggregate fulfilled its aim of the characterization of basic engineering properties. The general conclusion derived from the investigation is that RAC concrete has different characteristics than those of concrete made from comparable natural aggregate with the same amount of cementitious binder.

Based on experimental results conducted on Recycled aggregate concrete, the following observations can be made:

Optimum percentage of Compressive Strength of Cubes was found for the concrete produced from 20% and 40% replacement of Natural aggregate with 15% fly ash.

It is concluded that based on Strength Characteristics the optimum percentage of recycled coarse aggregate is 20% beyond 20% replacement of natural coarse aggregate strength increases.

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