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Recycling of Concrete Demolition Waste: pathway to sustainable development

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Abstract. Over the years, advancement in the construction industry and the need for change and improvement towards new structures have led to increase in the use of construction materials and generation of construction and demolition wastes (CDW). These construction wastes are aesthetically displeasing and not of good environmental impact. Its presence in the environment also occupies space. This study reviewed researches carried out independently by different researchers to establish the recycling of concrete waste for fresh construction purposes. This puts into consideration the integrity of new structures built from using these concrete wastes; hence researching into its impact on certain properties such as workability, compressive strength, water absorption and more. The line drawn from the distinct works established the possibility of recycling concrete wastes for further use in construction purposes with retention of structural integrity. The results from two research works compared established 25% to 30% optimum replacement level of recycled concrete with satisfactory structural properties.

Keywords: Aggregate, Construction and demolition waste, Recycled concrete Aggregate, Natural Aggregate, Construction Aggregate.

1. Introduction

Construction and demolition wastes (CDW) are regarded as wastes obtained from demolition sites or construction sites. Such wastes are generated through innovations, change in original approach to construction, building collapse due to failure of members and more [1]. Other activities can also include construction of concrete structures, steel structures, flyover, bridges, subway, and construction of roads [2]. The major way of disposal for this type of waste has been by landfill method but this method also has its negative environmental impact and can lead to contamination in the soil when leachate escapes into the earth. This calls for a better approach to managing construction and demolition wastes' generation and so there is a need to consider the recycling of these generated wastes for further use in construction [3].

In 2015, *Yadhu and Devi* stated that the demand of aggregate for construction worldwide has grown beyond 26.8 billion tons per year. After World War II, the use of demolished pavement for stabilization of base course began. The use of concrete in construction works is increasing very fast and this is leading in turn to increase in the use of natural aggregate as the largest composition of concrete. For instance, 2 billion tons of aggregates are produced yearly in the United State of America. Estimation shows that by the year 2020, aggregate production would have increased to more than 2.5 billion tons per year [4].

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In the world today, everywhere that was ever inhabited has concrete. Habitations such as residential houses, institutions, medical centers, road networks and industries. Despite these good constructions, the need for changes and modern infrastructure rise with time and these desires for modernized structures are potential mediums for construction waste generation [4-26]

Poovendiran, Mariappan, Thivya, and Jayganesh in 2015 said that the development of infrastructures in India is occurring at a very fast rate and due to longer life span and easy maintenance, concrete structures are more accepted. The commonly used concrete is manufactured through the use of natural sand gotten from river beds. About 30% of the new structural development are being developed on a site where previous structure has been demolished [27].

According to *Otoko* in 2014, Nigeria has increase in the volume of CDW generated and this is as a result of continuous increase in the development of infrastructures such as construction of roads and buildings. When buildings that are not rightly positioned are demolished, it leads to the generation of construction demolition wastes. In Port Harcourt, wastes of these likes are confirmed to be a good source of aggregate to manufacture new concrete and with such concrete proven to possess similar mechanical properties to that of conventional concretes.

In Egypt, the annual construction demolition waste is 4 million tons with landfill as the major method of disposal of the huge waste. This landfill approach has become of an environmental problem. A solution to the problems being generated by landfill method is to recycle the construction demolition wastes [28].

The main aim of this study is therefore to review the works carried out by researchers over the recycling of concrete wastes for further construction purposes and to further draw inferences on the possibility of its usage with relation to the required mechanical properties.

2. Recycling of Concrete Waste

According to *Kabir, Al-Shayeb, and Khan* in 2016, Solid waste management is a global challenge and a major one in the gulf region. Developments such as industrial growth, construction activities, lifestyle civilization and accelerated urbanization have led to tremendous increase in the challenges contributed by these wastes [1]. CDW management is an issue of concern because of the challenge of where to deposit the waste after its generation. Also, transportation of resulting volume of CDW and the cost of dumping of the generated wastes are also challenges worth noting. These degrade the environment [29]. Although, CDW is not a major threat to the environment but the view of it is aesthetically not acceptable and so it should be disposed with almost care [30].

According *Ganiron and Tomas* in 2015, Recycling of waste as component of environmental considerations has come to be a vital and common practice in the construction industry [3]. In recent decades, the reuse of CDW as aggregate material in recent construction has become common. The unavailability of natural aggregate and the deterioration of landfills suggest that CDW should be used as source of aggregate in the production of fresh concrete [29].

Wagih, El-Karmoty, Ebid, and Okba in 2015 said Wastes from demolition sites have several contaminants or foreign materials such as woods, plastics, finishes, steel, iron, dirt, cladding materials and more. In Egypt, heavy material such as bricks, mortar, tile residues, sand and concrete are located in Concrete demolition wastes. Concrete can be found to be 50% weight of the total waste [31].

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Recycled concrete aggregate has played a vital role in the preservation of natural resources. The continuous rate of industrialization demands for recycled concrete aggregate has made this so. There are many benefits to recycling of concrete waste, and some of these benefits are; the conservation of natural resources, reduction of impact on dwindling landfill spaces, reduction of disposal cost, and the reduction of overall project cost [32]. If recycled aggregate from old hardened cement paste is kept clean with all deleterious substance removed, it can be further used with natural aggregate mixes [33].

3. Results Review

3.1 Specific Gravity

Based on the research carried out by *Sonawane and Pimplikar* in 2009, the specific gravity of the recycled concrete aggregate used ranged between 2.35 to 2.58 with natural aggregate control that ranged between 2.4 to 3.0 [34] while the specific gravity of the recycled aggregate used by *Wagih, El-Karmoty, Ebid, and Okba* in 2012 ranged between 2.19 to 2.48 with natural aggregate control of 2.58 [31].

3.2 Compressive Strength

Sonawane and Pimplikar in 2009 carried out compressive strength tests on cubes cast using 10%,20% and 30% recycled concrete aggregate replacement for both 30 N/mm2 and 40 N/mm2 strength. The strengths remained satisfactory at 28 days of curing for 30% replacement of the recycled aggregate. Hence 30% recycled concrete aggregate replacement has satisfactory compressive strength [34]. In agreement to the 30% RCA replacement recommended by *Sonawane and Pimplikar* in 2009, *Wagih, El-Karmoty, Ebid, and Okba* in 2012 stated a considerable strength reduction for 40% RCA replacement while 30% RCA replacement remains satisfactory [31].

3.3 Water Absorption

The water absorption of the recycled concrete aggregate used for research by *Wagih, El-Karmoty, Ebid, and Okba* in 2012 ranged from 2.15% to 7.15% while that of Sonawane & Pimplikar in 2009 ranged from 1.5% to 7.0%. In 2013, *Husain and Assas* after carrying out the water absorption test concluded that the water absorption for RCA is more than that of NA due to high level of water demand of the old mortar attached to the original aggregate particles [35-36]. These results are higher than that of natural aggregate and hence acceptable.

3.4 Workability

According to the research *Yadhu and Devi* in 2015, when concrete demolition waste was used as fine aggregate with concrete, the result of the slump test gave 26 as its value, and this meets up with the required value (true slump value) which ranges between 25mm-30mm [4]. *Wagih, El-Karmoty, Ebid, and Okba* in 2012 also ascertained satisfactory slump test results for different 50 mixes.

3.5 Bulk Density

The bulk density of RCA is discovered to be lower compared to that of NCA. The high porosity of RCA may contribute to its bulk density [31].

3.6 Abrasion Value

The impact value and the abrasion value of RCA did not meet up with the specification of code of practice. These are seen to increase with increase in the level of recycled concrete aggregate.

3.7 Flexural Strength

Flexural strength is still satisfactory up to 30% RCA replacement [34]. In addition to the inferences drawn from the reviewed results, it is also seen that the use of silica fume as a mineral admixture enhances the performance of RAC [35].

4. Conclusions

Construction demolition waste is still useful and can be further reused in construction with its strength meeting up with the requirement of standard codes of practice. 25% to 30% replacement of recycled concrete waste in concrete production has satisfactory structural properties. Recycling of CDW is a major solution or answer to the problem being caused by the huge volume of CDW being generated consistently. When CDW is recycled, it is useful for reconstruction purposes.

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