USE OF RECYCLED CRUSHED AGGREGATES FOR CONSTRUCTION PURPOSE

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ABSTRACT:

This study aims to develop best economic solution by use of recycled aggregate in structural concrete to reduce the environmental impact around the globe. Therefore, the objective of this project is to investigate the hardness properties of Recycled Concrete Aggregate including density, compressive and tensile strength, modulus of elasticity and drying shrinkage. This is also to determine the durability, permeability, quality and cleanliness that are suitable for application in high strength concrete up to 60MPa compared with 100% natural aggregate from the pits around the globe, which is provided from local companies. To determining the above properties of the recycled aggregate by studying the influence of 100 percent recycled aggregate in concrete. The Laboratory trials were conducted to investigate the possibility of using 100 percent of recycled aggregate (20mm, 14mm and 10mm) with 25 percent of fly ash to replace part of the cement in concrete, compared with natural aggregate.

Keywords: *Aggregates; Concrete; Durability; Fly Ash; Recycle.*

1. Introduction

Reuse of the old building material by recycling it is the very old concept worldwide [1]. Throughout the globe the recycling of old structure or building material to create new ones is very common. After the II world war recycling becomes one of the best alternatives to compensate the economy loss [2]. Recycling is a very effective technique for the management of environment as it provides stability to the construction industry as well as eases the load of the environment. During the manufacturing of various types of construction material a lot of residue is left so there is a need of the hour to recycle or reuse that residue for the construction [3]. Recycling helps in the reduction of energy consumption. Recycled material is mainly used in the construction of roads and buildings [4].

The waste production, i.e. unnecessary or unwanted material is an unavoidable outcome of most of the production processes. Throughout the world, around 7 to 9 billion tons of waste is generated annually [5]. It has been estimated that India as a whole, produces as much as 25 million tones of metropolitan waste each year [6].

To minimize the solid waste produced by different construction sites and from the demolition of old structures or buildings, landfill method is commonly used [7]. But there are many disadvantages of this method as it require more land and labour for its operation. To overcome from this problem many researchers, engineers, contractors and architects use these waste materials for recycling purpose and produce recycled aggregates in huge quantity [8]. The use of recycled aggregates (RA) is one of the best environment friendly techniques. However, due to their dimension distribution reproducing that of the soil, there have been loads of attempts to integrate RA in geotechnical applications, chiefly as filling matter or in concrete. In that attempt the quantity of the hazardous material kept minimum and also the RA exhibit the minimum value for construction related properties [9-11]

1.1 Recycling of aggregates

In Europe the thirty one percent of the whole soil waste is generate through the construction industries [12. There are many sources of solid waste namely old buildings, demolished structures etc. There are some other sources (asphalt and concrete and embankment earth work) which acts as a major production house of the aggregates [13]. This solid waste used to dump in dump yard which produces land scarcity, pollution and sometimes these waste solids have very toxic particles which can be hazardous for human health as well as for environment, as a result, reduce, reuse and recycling turn out to be a need of the hour. These three R’s also helps in the reduction of reduce transportation price and also minimize the use of fossils fuels which are non renewable in nature. Utilization of the material in recycled form helps in the diminution in the consumption of natural aggregates.

Nowadays the demand for the natural aggregates increasing day by day as the developing countries like India, China etc works on the development of their infrastructure [14]. In 2015 the projected market value of natural aggregates was around 48 billion tons but it will expected to reach up to 66.3 bn tons by 2020 [15]. Many attempts are done to take the construction industry towards sustainable construction such as contractors and researchers use low carbon concrete. Researchers review the reuse of waste from construction sites, demolition sites and other waste which has been generated due to the natural disasters in Algeria [12].

1.2 Source of recycled aggregates

Most of the developed countries used these waste for recycling purpose and up to 90% of the CDW is being utilized for the manufacturing of recycled aggregates. There are various sources of material required for the preparation of recycled aggregates namely demolished buildings, broken roads and buildings due to the natural calamities such as earthquakes, Tsunami, floods, etc [16]. Usually fired bricks and concrete is the primary constituent for the production of RA [14].

2. Review of Literature

According to a March 2007 Hindu Online report, India generates 23.75 million tonnes of waste a year. According to the Central Pollution Control Board (CPCB) Delhi, India generates about 48 million tonnes of solid waste annually, of which 14.5 million tonnes is generated from the construction sector, but only 3% of the waste is used for bundles [17]. Urbanization in India has expanded immensely because of industrialization. India's development rate will reach 9% of GDP. Fast infrastructure development requires the accessibility of a lot of construction materials and land. The application of concrete is preferred for its better performance and longer working time and minimum maintenance expenditure [18].

Various investigations of RA have yielded positive outcomes when utilized in an assortment of road construction applications [19]. In general, performance minimizes when RA is incorporated from rock trash or black-top based materials [20]. But on the other hand when RA is added from crushed cement the performance increased [21]. This is because of oneself concrete properties of the crushed cement particles and the harsh surface of the un-hydrated concrete, which expands the intra-cell contact, which also prompts load redistribution. The leach ability of reused comprehensive works is significant for the construction of road and buildings. Wastes that are partially processed from construction to demolish possess exceptionally harmful components to ecosystem and human (e.g., lead based paints, fluorescent lights containing mercury, refined wood and asbestos) that accommodate groundwater [22].

2.1 General information about aggregates

Since 3-fourth of the concrete is controlled by aggregate, essential to investigate on the strength and durability of the substantial for effective application. The fixed piece of the concrete mix all in all with a concrete contents and is generally utilized as an inert material as a concrete paste for economic purposes. In fact, aggregate retain heat, water, chemicals, etc. Physical properties incredibly influence the concrete performance [23]. Aggregate gives more prominent amount and is less expensive contrasted with concrete [8].

2.1.1 Particle shape and texture

Classification	Description	Examples
Rounded	Fully water-worn or completely shaped by attrition.	River or seashore gravel, seashore, desert and windblown sand
Irregular Flaky	Naturally irregular, or partly shaped by attrition and having rounded edges.	Other gravels, Laminated rock land or dug flint
Angular Elongated	Possessing well-defined edges formed at the intersection of roughly planar faces	Crushed rocks of all types talus, Crushed slag
Flaky Elongated	Material having the length considerably larger than the width, and the width considerably larger than the thickness	

2.2 Recycled aggregates: Its properties

The performance of the reused aggregate determined to b equivalent to the fresh base coarse total. Additionally, it was expressed that a 10% fine test is reasonable as an assessment test to survey the compressive strength of the original material. SIO (2001) breaks down the physical and designing properties of reused concrete aggregate and the properties produced for the utilization of reused concrete aggregate in asphalt base courses [24]. In light of the outcomes, it is suggested that the Los Angeles friction misfortune loss to be less than 48% for the utilization of reused gravel rock as a base material on adaptable sidewalk. In addition it was suggested that the Na_2SO_4 test not to be applied and reused concrete aggregate [25].

Sean Mulligan (2002) [26] did adequacy testing on virtually all Reinforced Concrete Materials (Freeze/and Los Angeles Abrasives) and Gravel (Limestone and) Freeze/Recycle Concrete Materials. Gravels that are greater than or equivalent to molecule size (4.75-mm strainer). For sufficiency testing by Los Angeles Abrasives, reused concrete materials are not as solid or stability as gravel. Researcher researched the properties of reused aggregate made of crushed concrete and reported that the properties of crushed reused aggregate in various times were practically the same. Additionally, it has been accounted for that the volume distribution of reused gravel shifts with different ages just as different attributes, for example, water ingestion, bulk specific gravity, bulk density, concrete substance and crushing value [27].

3. Application of recycled aggregates

Kuosa, 2012 gave guideline to indicate industrially produced reused concrete aggregate for pre-blend production of concrete dependent on item viability tests led by CSIRO. In view of the item diversity test of industrially accessible reused concrete aggregate, could reused concrete aggregate and can be effectively utilized for underlying applications or as a component of the production of premium concrete as a whole [28].

Taha et al., 2002, Cement Stabilized Asphalt Pavement (RAP) Total and research facility assessment of guaranteed base material asphalt - affirmed by results: 100% recuperated bitumen clearing total can be utilized effectively as a regular base material when settled with concrete. Asserted bitumen rock seems, by all accounts, to be an option in contrast to the dense grade concrete utilized inroad base and sub-base construction [29]. Park (2003) led research in laboratory and field studies to explore the properties and execution of dry and wet reused concrete aggregate as base and subbase materials for concrete asphalts [30].

Khalaf and Divini (2004) inspected research work on the utilization of coarse aggregate in new concrete, particularly crushed bricks. The survey revealed that reused rock is primarily utilized as a sub-base material or as a covering layer in road construction [31]. Fong et al. (2004) explained about the most recent application experience utilizing reused aggregate in construction projects in Hong Kong after leading conducting a case study is and demonstrated that reused aggregate can produce quality cement for primary applications [32].

4. Methods to analyze the different parameters of recycled aggregates

4.1 Aggregate Impact Value and Aggregate Crushing Value (AIV and ACV)

The crushing value is obtained by measuring the total loss in the mass of aggregate when it passes through the sieve of size 2.36mm [33]. The quality of the aggregate depend s on the crushing value of the aggregate. Higher crushing values of aggregates leds to the formation of inferior quality of the aggregates where as lower crushing value of the aggregates leds to the formation of aggregate of superior quality [34].

Calculation:

Aggregate crushing value: W1/W2 * 100 (Per cent)

Here,

W1= Whole weight of dry material.

W2= Weight of the matter passing through the 2.36mm sieve.

4.2 Water absorption test (WAT)

It is described as amount of assimilation of water by a specific RA. WAT is obtained by calculating the difference between the oven dry sample and wet sample which is immersed in water for whole day. The absorption value is always given in percentage [35]. The standard procedure is prescribed in BS. Absorption values of the RA are supposed to affects the bond between RA and cement paste. Also higher value of water assimilation of RA reduces the workability of concrete whereas the low value of water assimilation of RA boosts the workability of concrete [33].

Calculation:

Total weight of dry sample = W1

Measured weight of saturated specimen = W2

Amount of water immersed= W= W2-W1

Percentage of assimilated water= W2-W1/W1 * 100

4.3 Importance of water absorption test

The high water absorptivity of the recycled aggregates minimized the compressive strength also reduced the resistance capacity of aggregate to freezing [36-37].

4.4 Sieve analysis of sand

Distribution of Sand particles in sand is one of the important parameter which is used to check the superiority mortar and concrete. The gradation of sand particle is obtained by Sieve test Analysis in which the sample is moved through the various sieves of different size which are arranged in a descending order i.e. the sieve having bigger size is placed on the top of the setup and the sieve with minimum size is placed at the bottom of the setup. During the process the Sand particles are retained on the sieve of different sizes. The weight of the retained sand on the different sieves is measure to calculate the distribution of different particle size of the sand in coarse sand. Distribution of particle size is always shown in percentage [38].

Sieve analysis of aggregate is a method employed to evaluate the distribution of particle size of a coarse aggregate. The distribution of particle size is frequently of significant importance in the way material performed in use. The method of sieve analysis can be

achieved on any kind of organic or inorganic material including senols, rocks, clay, coil or soil. Being such a simple technique of partial sizing, it is the most frequently used method in all probability [39-40].
Calculation:
Fineness modulus: Σ (Cumulative % of water retained) / 100

4.5 Crushing strength of concrete

In 1948 a test was developed by Schmidt Hammer which provides a fast, affordable, easy way to check the crushing strength of concrete. This method relies on the Rebound principle, and to carry out this method, piston of the machine is push down powerfully towards the concrete. There are many advantages of this test but have some limitations too.
This method might be used to obtain the uniform value of concrete and to compare the different investigation by drawing contour lines for Rebound number [41].

5. Result and Discussion

5.1 Sieve analysis of coarse aggregates

Generally the particle size of coarse aggregates is always bigger than 4.75mm, but sometimes their diameter varies from 9.5mm to 37.5mm. There are three main sources of coarse aggregates namely 1^o, 2^o and recycled sources. Land and Marine-won acts as 1^o source of aggregates. Secondary aggregates produced as by-products of extractive operations and from various types of materials. Recycled concrete is a feasible source of aggregate and has been adequately used in granular subbases, soil-cement, and for the manufacturing of new concrete.

S.no.	Sieve Size	Weight of aggregate retained	% of weight retained	Cumulative %
1	80	0	0	0
2	40	1385	29.85%	29.85
3	20	1745	37.61%	67.46
4	12.5	210	4.53%	71.99
5	10	225	4.8%	76.84
6	4.75	905	19.50%	96.34
7	Under 4.75	145	3.125%	99.465

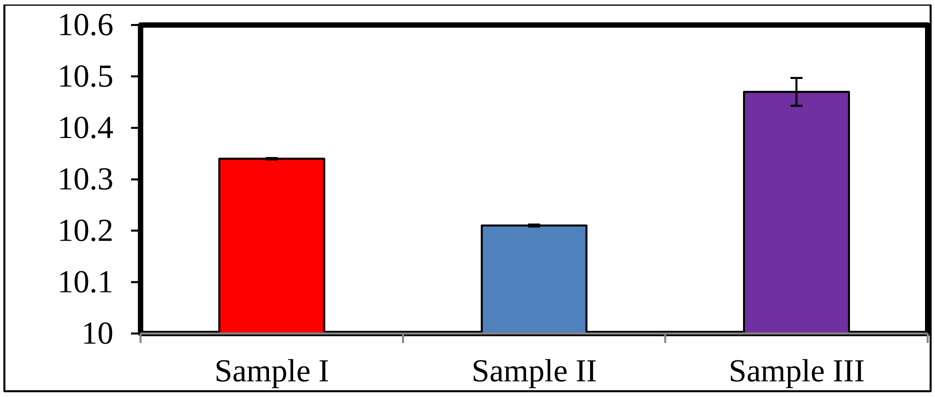
Fineness modulus = Σ Cumulative %/ 100
Fineness modulus = 29.85+67.46+71.99+76.84+36.34+99.465 / 100 = 444.945/100
Fineness modulus = 4.41
Result: Fineness modulus for the given coarse aggregates is 4.41

5.2 Aggregate impact value

The aggregate impact value gives a relative measure of the resistance of an aggregate to sudden shock or impact, which in some aggregates differs from its resistance to a slow compressive load [42].

S. No	A	B	Mean ± S.D (Aggregate Impact Value in %)
Sample I	377	39	
	377	38.5	10.34 ± 0.0013
	377	39.5	
Sample II	386	45	
	386	46	11.69 ± 0.00196
	386	44.5	
Sample III	390	48	
	390	50	12.51 ± 0.02706
	390	48.5	

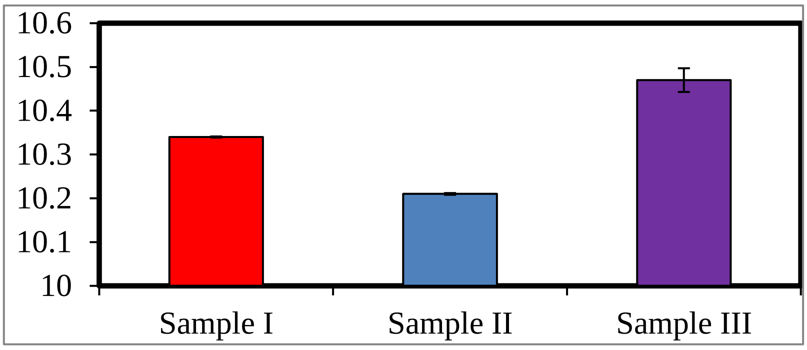
Here:
A = Net weight of aggregate in the measure (in gram).
B = The fraction passing through 2.36mm IS Sieve (in gram).
Aggregate Impact value = B/A * 100
Aggregate Impact value range 10-20 % is classified as strong [43].
The mean aggregate impact value of Sample I is 10.34%
The mean aggregate impact value of Sample II is 11.69%
The mean aggregate impact value of Sample III is 12.51%
In our result mean aggregate impact value of all the three samples comes in the range 10-20%
Minimum is for Sample I and Maximum for Sample III.
This shows that all three samples can be placed under strong category.



5.3 Water absorption of Aggregate

Samples	W_A	W_B	Mean ± S.D (Water absorption of Aggregate in %)
Sample I	2000	2008	
	2000	2007	0.416± 0.076376
	2000	2010	
Sample II	2100	2104	
	2100	2112	0.39 ± 0.191398
	2100	2109	
Sample III	2200	2214	
	2200	2216	0.57 ± 0.18735
	2200	2208	

Here:
W_A= Dry weight of aggregate in gram
W_B= Weight of aggregate immersed in water
Aggregate water Absorption= W_B-W_A/W_A* 100
The water absorption value less than 2% than the material is suited for construction.
Mean value of aggregate water absorption of Sample I is 0.41%
Mean value of aggregate water absorption of Sample II is 0.39 %
Mean value of aggregate water absorption of Sample III is 0.57%
In our study the mean value of aggregate water absorption of all three sample comes below 2% this shows that all the three samples are suitable for the purpose of construction.



6. Conclusion

This research work was conducted to examine the use of fine RA as fractional or universal replacements of natural fine aggregates in the creation of structural concrete. The research work shows that it is feasible to generate concrete made with fine RA appropriate for structural concrete, taking into account that:

1. The compressive potency does not appear to be exaggerated by the fine aggregate substitution ratio, at least for up to 30% substitution ratios and the strength levels measured in this study;

2. Modulus of elasticity as well as tensile splitting is minimized with the amplification of the replacement ratio; however, the values obtained for both features are still good enough, particularly for reasonable levels of the replacement ratio (30%);

3. The scrape confrontation seems to enhance with the replacement of fine natural with fine RA.

It has been examined that the recycled coarse aggregate is used as normal aggregate. The workability of the concrete is increased by using RA. Maximum properties of RA have shown good with a little variation. Recycled aggregate materials produce harsh mixes with lower workability than Natural aggregates. New standards should be introduced for recycled aggregates so that these materials can be used successfully in future.

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