A Review on sustainability of Recycled Construction Aggregates

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Abstract- Construction industry is based on the adequate supply of raw materials. The rapid urbanization and industrialization have put strain all resources. This ever-increasing demand and the shortage of natural aggregates has put a need to find new sources or alternatives for aggregates. Recycling old materials and reusing them again can also prove to be an effective and economical solution for shortage of aggregates. It will protect natural resources and reduce disposal issues of construction and demolition waste. Several attempts are made in this regard by replacing natural aggregates by recycled construction aggregates (RCA) in different proportions by weight and prepares concrete mix is tested for fresh and hardened properties. All attempts although are successful enough to promote the use of RCA but the results reveal concrete with reduced strength or additional admixtures is required to attain original strength. Thus it increases overall construction cost. Present review is made to put forward these issues with RCA and efforts made to develop cost-effective solution to find sustainable recycled aggregates.

Keywords- *C&D waste, Recycled aggregate, Natural Aggregate, compressive strength, workability*

I. INTRODUCTION

Market demand for coarse aggregates is 26.8 billion tons per year globally [1]. As per records approximately, only 10 billion tons need is meet through sand and natural rock whereas 11 billion tons of construction waste is produced annually [2], out of which concrete accounts about 50 to 70% [3, 4]. This concrete consumes a huge amount of cement. And the cement industry is a major cause of greenhouse emissions (7% of CO_2 emission globally) [5, 6, 7, 8, 9]. It clearly reflects a requirement of a reliable source of providing aggregates for mass concrete production. The concrete thus prepared using construction and demolition waste is termed as Recycled construction aggregates (RCA). This concrete has proven to be a step towards meeting increasing demands of concrete production. Using or recycling construction waste as aggregate will help to reduce the amount of waste and preserve natural resources [10], reduce the strain of landfilling activity of construction waste [11], also RCA use will be more economical as it reduces transportation cost and landfilling debris activity in case of demolition waste [12].

II. NECESSITY OF RCA:

Natural aggregates are basically coarse and fine aggregates. These resources are limited in nature and due to excess demand, there is a need to find an alternative for natural aggregates. Also, the construction industry is facing a problem regarding the disposal of construction waste. These two issues are brought together and a solution of derived of using this waste as an alternative for natural aggregates. By reuse of recycling the construction as well as demolition waste, stress on natural resources is reduced, also it seems to be an economical solution to solve the above two problems. Construction waste has to suitably derived from the site and feed to a recycling plant to get recycled construction aggregates. The waste from the site cannot be used directly. It must be first sorted, segregated and grouped together as per similar properties and strength parameters. Recycled aggregates are added in the percentage of natural aggregates as partial replacement material.

Sources of RCA:

- Construction waste (rubble, brick, concrete etc.)
- Soil and Rocks excavated from the foundation
- Rubble from the demolition of roads
- Structural and non-structural demolition waste

Recycling Procedure adopted to derive RCA [13]:

- Proper identification, classification, and sorting of waste
- Developing different techniques and management practices for the proper recycling of construction waste
- Government incentives and tax exemption for reuse of waste
- Imposing heavy charges/ taxes for landfill site and direct disposal of waste
- Provide training for effective recycling and reuse of waste
- Make future provision of recycling the concrete during its design and execution stage

Problems associated with RCA [13]:

- **High-cost investment for:**
  a) Sorting procedure
  b) Transportation of waste
  c) On-site or plant crushers
- ***Management level***
  a) Company policies cannot change within one day
  d) Unskilled labour
  e) Lack of training
- ***Logistics***
  a) Recycled products have reduced quality
  b) Limited applications
  c) Continuous supply not available
  d) Still proper segregation technique not available
- **Ecological Issues:**
  a) Heavy excavation at quarries
  b) Strain on landfill site

III. LITERATURE REVIEW:

On summarizing, there are different options for recycling of construction waste, but these procedures are associated with different issues. When demolished concrete is crushed, a certain amount of mortar and cement paste remains adhered to stone particles in RCA [14, 15]. This adhered material is the main factor affecting properties such as density, porosity, and water absorption of RCA. The density of RCA lowers by 7 to 9%, porosity increases by 4 to 6% which makes RCA hold more water in its pores than natural aggregates (NA) [16, 17]. Presence of unwanted substances in derived RCA like mortar, ceramics, wood, soil, plastic, glass etc is also a major issue. Their fractional presence in RCA can cause a significant decrease in concrete compressive strength [18, 19]. It is observed that RCA normally have higher water absorption and lower specific gravity than NA [20]. These crushed aggregates are not suitable for structural concrete due to its porous nature.

Efforts have been made to provide epoxy resins coating to these aggregates to minimize its water absorption [21]. Results were remarking but cost extra amount for coating of aggregates. Even the pre-soaking method was adopted; it consists of pre-soaking aggregates to remove dust particles. This helps in reducing water demand. And removal of dust particles has shown an increase in compressive strength by 8 % as compared to untreated RCA. It revealed that in order to achieve higher compressive strength it requires lower granulation index, lower mineral dust content and lower water absorption [22]. Although it can be considered an effective solution for using RCA but still we are living in an era of acute water scarcity, so such method although correct but not practically effective. By using 100% RCA in concrete it would require 16% more water than normal concrete, this problem was also worked out by using water reducer admixture to attain the desired workability and desired strength [23].

It is also observed that while deriving RCA from construction waste, crushers are feed with construction/ demolition waste from heterogeneous sites consisting of concrete with random aggregate content. It may also contain organic impurities, wood and fibre-board particles, paper, thrash etc. Presence of such impurities in RCA will provide concrete with reduced compressive strength by about 20 %. Such concrete can certainly be not used for structural concrete demand. The main reason for this is its unpredictable behaviour and properties [24]. When talking about the durability of concrete consisting of RCA, certainly the values are lower as compared to natural aggregate concrete. Durability issue is resolved by using appropriate mineral admixture [25]. But admixture adds to the extra cost.

To rule out proper selection procedure of RCA, RCA was added into the concrete mix at different percentage level and compared with NA concrete. To determine the amount of cement adhered to aggregates, the sample is immersed in acid and reduction in weight is examined to determine how much cement paste reacted with chloride present in acid. Results showed that RCA concrete has a higher percentage of cement paste that adhered to aggregates and these reacted aggressively with acid [26]. During the assessment of RCA concrete, it showed a reduction in setting time and loss of workability to a greater extent, this made concrete difficult to handle during its early stage [27]. Use of RCA leads concrete to have higher shrinkage and creep strain [28]. RCA aggregate use is associated with an acute problem of bleeding in fresh concrete, thus affecting its workability significantly. [29, 30, 31, 32, 33]

IV. CONCLUSION:

Past literature review shows noticeable work done on the use of recycled aggregates in concrete. By adding RCA in the concrete mix, its fresh and hardened properties are worked out. Efforts are made to achieve concrete of desired strength and durability. But merely adding RCA has given lower values. Efforts are made to improve properties of concrete consisting of RCA. But there is a research gap between demand and type of product supplied. At present RCA concrete is assessed for durability and strength after addition of construction or demolition waste. But there is a need to make a process change

so as to obtain good and desired aggregate each and every time when procured from crushing plants irrespective of heterogeneous waste feed to crushers. Developing proper segregation mechanisms and further develop a proper assessment for recycled aggregate concrete for all parameter similar to normal aggregate concrete. Surely this new concrete must have different acceptance parameters and they must be different from normal concrete. Also, different admixture material to be used should be standardized after thorough investigation and testing.

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