

# Use of Recycled Concrete Aggregate in Concrete Pavement Mix

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## ABSTRACT

A number of investigations have been carried on the mechanical properties, durability and structural performances of recycled aggregate concrete (RAC). The application of recycled aggregate to use in construction activities have been practice by developed European countries and also of some Asian countries. We know that concrete is the main construction material across the world and the mostly used in all types of civil engineering works. As aggregate represents about 70-80% of concrete components, so it will be beneficial to recycle the aggregate for construction works and also to solve the environmental problems. In this paper a study has been made on the past researches carried out by the different scholars and their results have been studied.

Keywords: Recycled aggregate concrete (RAC), Performance of recycled aggregate concrete, compressive strength.

## INTRODUCTION

Recycling is the act of processing the used material for use in creating new product. The usage of natural aggregate is getting more and more intense with the advanced development in infrastructure area. In order to reduce the usage of natural aggregate, recycled aggregate can be used as the replacement materials. Recycled aggregate is comprised of crushed, graded inorganic particles processed from the materials that have been used in the constructions and demolition debris. These materials are generally from buildings, roads, bridges, and sometimes even from catastrophes, such as wars and earthquakes. Traditionally, the application of recycled aggregate is used as landfill. Nowadays, the applications of recycled aggregate in construction areas are wide. The applications are different from country to country. Recycled aggregate has been used as concrete kerb and gutter mix in Australia. According to Building Innovation & Construction Technology (1999), Stone says that the 10mm recycled aggregate and blended recycled sand are used for concrete kerb and gutter mix in the Lent Hall Street project in Sydney. The major advantage is based on the environmental gain.

A. Recycled Aggregate Concrete Recycling is the act of processing the used material for use in creating a new product. The usage of natural aggregate is getting more and more intense with the advanced development in infrastructure area. Recycled aggregate is comprised of crushed, graded inorganic particles processed from the materials that have been used in the constructions and demolition debris. Recycled aggregates are produced from the re-processing of mineral waste materials, with the largest source being construction and demolition waste. These wastes are normally composed of concrete rubble usually, constitutes the largest proportion of C&D waste. It has been shown that crushed concrete rubble, after separation from other C&D waste and sieved, can be used as a substitute for natural coarse aggregates in concrete or a sub-base or a base layer in pavements.

## Literature Review

Okorie Austine Uche (2008) [1], studies the influence of recycled aggregate concrete (RCA) as a substitute for virgin coarse aggregate in the compressive strength of plain concrete and concluded the use of recycled concrete aggregates (RCA) as alternative to natural or virgin aggregate in structural concrete reduces the strength development of the concrete. Ismail Abdul Rahman et al (2009) [2] presented the effects of size of Recycled Aggregate on compressive strength and found that the compressive strength has been improved. Mirjana Malešev et al (2010) [3] performed comparative analysis of the experimental results of the properties of fresh and hardened concrete with different

replacement ratios of natural with recycled coarse aggregate and the author found the results on the basic properties of concrete with three different percentages of coarse recycled aggregate content (0%, 50% and 100%). He found that workability of concrete with natural and recycled aggregate is almost the same if —water saturated—surface dry recycled aggregate is used. Bulk density of fresh concrete is slightly decreased with increasing quantity of recycled aggregate.

#### Application of Recycled Aggregates:

- It helps to promote sustainable development in the protection of natural and reduces the disposal of demolition waste from old concrete.
- Recycled concrete can be also used in the production of concrete for pavements, shoulders, median barriers, sidewalks, curbs and gutters, building and bridge foundation.
- Growth in the use of recycled concrete for retaining wall backfill, port land cement concrete mix, landscaping rock, drainage aggregates, and erosion control is also happening.

#### Comparison of Past studies

Year	Test Carried	Results
2009	6 mixes were made and the various test has been conducted	The size of RA will affect the strength in compressive strength, the results show the 10mm and 14mm size of RA is better than 20mm size.
2011	Study of Assessment of Recycled Aggregate Concrete	RA can be used in concrete and that there is few (if any) applications issues related to its use
2014	Properties of recycled aggregate and their comparison with natural aggregate has been studied	The specific gravity, water absorption and Los Angeles abrasion clearly indicate that RCAs are of lower quality than NCAs as they contain mortar.
2017	Quarry dust is used in place of natural river sand and then compressive strength test and tensile strength has been carried out	The compressive strength and tensile strength of 45% replacement gives 31.92 N/mm <sup>2</sup> and 3.85 N/mm <sup>2</sup> respectively at 28th day of curing
2018	Recycled aggregate containing silica fume was used as the partial replacement of cement and various tests has been carried out	The increase of recycled aggregates content beyond 30% has a negative effect on compressive strength of recycled aggregates concrete. The reduction in compressive strength after 28 days is about 10% when 50% recycled aggregates are used.

Table No.01

### Recycling Process

Recycling plant normally located in the suburbs of cities due to the noise pollution that make by the equipment's that used during recycling process. According to Aggregate and Quarry (n.d.), all the machinery used have to fit with the effective mufflers to reduce the noise from the processing activity. The main reason that choosing the structural building as the source for recycled aggregate is because there is a huge amount of crushed demolition Portland cement concrete can be produced. The equipment's that used during recycling process are various from the site conditions and also country to country. There are few different types of equipment had been used effectively to break up the Portland cement pavement and structural building. Recycling of Portland Cement Concrete mentioned that there are few different types of equipment had been used for crushing the Portland cement pavement. The equipment's are as below: (a) Diesel pile – driving hammer. It is mounting on a motor grader that sticks in the Portland cement pavement on around 30cm grid pattern. (b) Rhino – horn – tooth – ripper – equipped hydraulic excavator. It is used to remove all the steel reinforcement that remaining in the Portland cement pavement. Crushing is the initial process of producing the construction and demolition debris into recycled aggregate. The concrete debris is crushed into pieces in this process. Aggregate and Quarry (2001) stated that generally the equipment's used for crushing process are either jaw or impacted mill crushers. It also stated that all the recycling crushers have a special protection for conveyor belts to prevent damage by the reinforcement steel that in the concrete debris. They are fitted with the magnetic conveyors to remove all the scrap metal. According to Recycling of Portland Cement Concrete (n.d.), the equipment's used to crush and size the existing concrete have to include the jaw and cone crushers. The concrete debris will break down to around 3 inches by the primary jaw crusher. It also mentioned that the secondary cone crushers will breaks the materials to the maximum size required which vary between  $\frac{3}{4}$  and 2 inches. Screening is the process that separates the various sizes of recycled aggregate. The screening plant is made of a series of large sieves separates the materials into the size required. Recycling of Portland Cement Concrete (n.d.) stated that the size of screen that used to separate the coarse recycled concrete aggregate and fine recycled aggregate is  $\frac{3}{8}$  inch. The size of screen used to separate the coarse recycled aggregate can be under or over  $\frac{3}{4}$  inches. It also stated that one more screen should be used to separate those particles that more than the specified size. All the recycled aggregate are stored according to the different size of aggregate. According to Recycling of Portland Cement Concrete (n.d.), the stockpile has to prevent from the contamination of foreign materials. It also mentioned that the vehicles used for stockpiling have to be kept clean of foreign materials.

Comparison of Recycled Aggregate and Natural Aggregate Recycled aggregate has the rough – textured, angular and elongated particles where natural aggregate is smooth and rounded compact aggregate. According to Portland Cement Association, the properties of the freshly mixed concrete will be affected by the particle shape and surface texture of the aggregate. The rough – texture, angular and elongated particles require much water than the smooth and rounded compact aggregate when producing the workable concrete. The void content will increase with the angular aggregate where the larger sizes of well and improved grading aggregate will decrease the void content. The quality is different between recycled aggregate and recycled aggregate. According to Segoe and Brown (1998), the quality of natural aggregate is based on the physical and chemical properties of sources sites, where recycled aggregate is depended on contamination of debris sources. It also stated that natural resources are suitable for multiple product and higher product have larger marketing area, but recycled aggregate have limited product mixes and the lower product mixes may restrain the market. The density of the recycled concrete aggregate is lower than natural aggregate. Segoe and Brown (1998) stated that when compare with natural aggregate, recycled concrete aggregate have lower density because of the porous and less dense residual mortar lumps that is adhering to the surfaces. When the particle size is increased, the volume percentage of residual mortar will increase too. The strength of recycled aggregate is lower than natural aggregate. Segoe and Brown (1998) stated that this is due to the weight of recycled aggregate is lighter than natural aggregate. This is the general effect that will reduce the strength of reinforcement concrete

Experimental Test Results



Fresh Aggregate

Recycled Aggregate

Aggregates Specific Gravity and Water Absorption Water absorption is defined as the absorption rates of water by aggregate. It is determined by measuring the increase in mass of an oven dried sample when immersed in water for 24 hours. The ratio of the increase in mass to the sample, expressed as a percentage, is termed of absorption (Neville, A. M., 2002). The standard procedure is prescribed in IS :2386(Part III)-1963. The absorption rate not only affects the bond between the aggregate and cement paste but also the specific gravity of the aggregate. When the water absorption of the aggregate is higher, it will decrease the workability of fresh concretes. Past researchers had proved that the absorption rates of recycled aggregate are higher compared to natural aggregate The absorption rate gives the effect to the mix proportions in control water content and to maintain water-cement ratio constant. That means, in concrete design, the higher absorption gives the problems for workability and water demand. The specific gravity is cluster under three different conditions namely bulk, apparent and saturated specific gravity. The bulk specific gravity is where the specific gravity of the aggregate is determined under the natural environment. The apparent specific gravity is determined after the aggregate is oven dried for 24 hours. The saturated specific gravity is determined when the aggregate is under the saturated condition. The specific gravity of an aggregate gives valuable information on its quality and properties and it is seen that the higher the specific gravity of an aggregate, the harder and strong it will be (Gambhir, M. L.,2004). The results show that the specific gravity values of RA are almost equal of the NA. This indicates that the qualities of RA are almost the same of the NA and can be used in any concrete mix.

	Mass of saturated surface dry sample, W2 (Kg)	Mass of (flask+ water+ sample) W3, (Kg)	$G = \frac{W2}{\{W2 - (W3 - W4)\}}$	G avg.
1	0.5	1.88	2.8	
2	0.5	1.874	2.72	2.72
3	0.5	1.868	2.63	

Table No.02 Specific Gravity (Natural Coarse Aggregate)

	Mass of saturated surface dry sample, W2 (Kg)	Mass of (flask+ water+ sample) W3, (Kg)	$G = \frac{W2}{\{W2 - (W3 - W4)\}}$	G avg.
1	0.5	1.84	2.29	
2	0.5	1.85	2.48	2.47
3	0.5	1.87	2.57	

Table No.03 Specific Gravity (Recycled Coarse Aggregate)

## CONCLUSION

- From the above study the following conclusions can be drawn.
- It is clear that recycled aggregate can be used with natural aggregates.
- Higher ratio of Recycle aggregate can worsen the properties and strength of mix.

- Due to use of recycled aggregate in construction industry it can slow the impact of waste on environment.
- Furthermore, improvement is needed in the recycled aggregated cement.

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