Review on Impact of Construction and Demolition Waste on the Properties of Concrete

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***Abstract*: Construction and Demolition (C&D) waste constitutes a major portion of total solid waste production in the world, and most of it is used in landfills. It is also becoming a serious environmental problem in many countries in the world. Construction and demolition debris frequently makes up 10-30% of the waste receive at many landfill sites around the world. This study reviews about the Recycled Aggregates (RA) produced from C&D waste and their use in concrete construction. Along with a brief overview of the engineering properties of recycled aggregates, the presentstudy also gives a summary of the effect of use of recycled aggregate on the properties of fresh and hardened concrete. The paper concludes by identifying some of the major barriers in more widespread use of RA in recycled aggregate concrete.**

***Keywords:*Construction and Demolition Waste; Strength; Workability; Sustainability**

1. Introduction

Construction and demolition (C&D) waste is generated from construction, renovation, repair, and demolition of houses, large building structures, roads, bridges, piers, and dams. C&D waste is made up of wood, steel, concrete, gypsum, masonry, plaster, metal, and asphalt. C&D waste is notable because it can contain hazardous materials such as asbestos and lead. Estimates vary, but a commonly accepted estimate is that between 15% and 20% of municipal solid waste comes from construction and demolition projects.Shahidan et al., (2017) investigated that the research is focused on the effectiveness of using treated or recycled aggregates as a replacement for common aggregates to produce a concrete structure.The values of the slump test falls within the range of 30mm to 60mm. The highest value recordedapproximately 50mm for aggregate size of 5 mm and 10 mm and the lowest slump value was 40mm for sizeof 20mm and 37.5mm.

Based on the research ofzuki et al.,(2017) the highest rate of water absorption is at about 10.60 % for aggregates size 37.5mm. Meanwhile, the lowest rate of waterabsorption is at 2.26 % for the 5 mm size of aggregates. As for the size of 10 mm, 14 mm and 20 mmaggregates, the results are 3.20 %, 4.00 % and 5.00 % respectively.

Construction and Demolition (C&D) waste constitutes a major portion of total solid waste production in the world. Research by concrete engineers has clearly suggested the possibility of appropriately treating and reusing such waste as aggregates in new concrete, especially for lower level applications. Recycled aggregates were also treated with epoxy resin to reduce the water absorption. The recycled aggregates that are obtained from site-tested concrete specimen make good quality concrete. Recycled aggregate concrete was found in the close proximity to normal concrete in terms of split tensile strength and compressive strength. The slump value of recycled aggregate concrete was low and that can be improved by using saturated surface dry (SSD) coarse aggregate(Zuki et al., 2017).

Research by concrete engineers has suggested the possibility of use of appropriately treating and reusing C & D waste as aggregate in new concrete, especially in lower level applications. Rao et al., (2005) also discusses different aspects of the problem beginning with a brief review of the international scenario in terms of C&D waste generated, recycled aggregates (RA) produced from C&D waste and their utilization in concrete. In the study of trocoliabdondantas et al., (2017), Artificial Neural Networks (anns) models were developed for predicting the compressive strength, at the age of 3, 7, 28 and 91 days, of concretes containing Construction and Demolition Waste (CDW). The experimental results used to construct the models were gathered from literature. The results obtained in both, the training and testing phases strongly show the potential use of ANN to predict 3, 7, 28 and 91 days compressive strength of concretes containing CDW.

2.Properties of construction and demolition waste

The review of properties of recycle aggregate is shown in Table 1.

Table 1.Properties of Recycled Aggregate

Properties	**Rao et al., (2005)**	**Katz et al., (2003)**	**Shahidanet al., (2017)**
Nominal max size mm	20	20	20
Fineness modulus	6.79	6	6.2
Bulk densitykg/m3	12.50	12	11.5
Specific gravity	2.53	2.6	2.42
Porosity%	5.03	6	6.5
Absorption%	2.03	2.5	2.7
Moisture content %	1.57	1.9	2.2

3. Effect of C & D waste on the properties of concrete

3.1Effect on fresh properties of concrete

3.1.1 Workability

According to the results obtained by Katz et al., (2003) the values of the slump test falls within the range of 30mm and 60mm. The highest value recorded approximately 50mm for aggregate size of 5 mm and 10 mm and the lowest slump value was 40mm for size of 20mm and 37.5mm. The small scale sizes of aggregates were absorbed less water compared to the larger size of aggregates. This happened because of the less surface area for small scale size aggregates will be less water absorption in the aggregates.The workability of RAC recycle aggregate for the same water content in the concrete is lower as reported by many researchers, especially when the replacement levels exceed 50%. The air content of the RAC is found slightly higher (~4% to~5.5%) than concrete made with NA at 100% replacement.The variation of workability is shown in Figure 1.

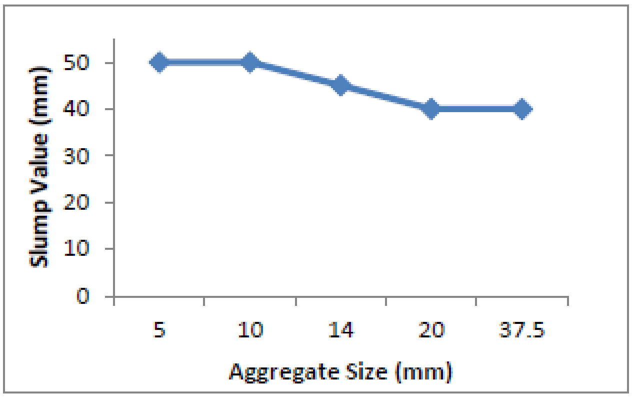

Figure 1. Variation of Slump (Katz et al., 2003)

3.2Effect on hardenedproperties of concrete

3.2.1 Compressive strength

Though researchers have reported a reduction in strength in RAC, it should be noted thatthe extent of reduction is related to the parameters such as the type of concrete used for making the RA (high, medium or low strength), replacement ratio, water/cement ratio andthe moisture condition of the recycled aggregate (Crentsil et al., 2001; Ajdukiewiczandkliszczewicz, 2002). Katzet al., (2003) found that at a high w/c ratio (between 0.6 and0.75), the strength of RAC is comparable to that of reference concrete even at a replacement level of 75%. Rao (2005) found the strength of RAC and reference concrete to be comparable even at 100% replacement, provided that the water–cement ratio was higher than 0.55. However, as the water–cement ratio is reduced to 0.40, the strength of RAC was only about 75% of the reference mix. Apart from the water–cement ratio, the moisture condition of the RA also appears to affect the compressive strength. Limited work has been reported attempting to relate the strength to the condition of the aggregates (oven dried, air dried, saturated surface dry, etc.), though the findings are inconclusive (Poon et al., 2004).The variation of compressive strength is shown in Figure 2.

Shahidan S et al., (2013) found thatthe results for compressive strength in 7 days increased dramatically from 14 mpa (5 mm) up to 29.6 mpa (10 mm). The size of 20mm aggregate was recorded the highest strength at 33.1 mpa, followed by the second highest strength achieved approximately 32.5 mpa for size of 37.5 mm. For the specimens cured for 28 days, the compressive strength sharply changed from size of 5 mm (13.8 mpa) up to aggregates size 10 mm (41.1 mpa).Kudus et al., (2012)and Hao W.,(2016) found that the bigger mean size of aggregates result in the greater compressive strength of concrete.The bigger aggregates result in a larger ITZ (Inter-facial Transition Zone) which refers to the weak binder zone around the aggregates which is more susceptible to cracks.This increases the chances of cracks occurring. Internal bleeding can take place when water gets trapped on the underside of large size aggregates.

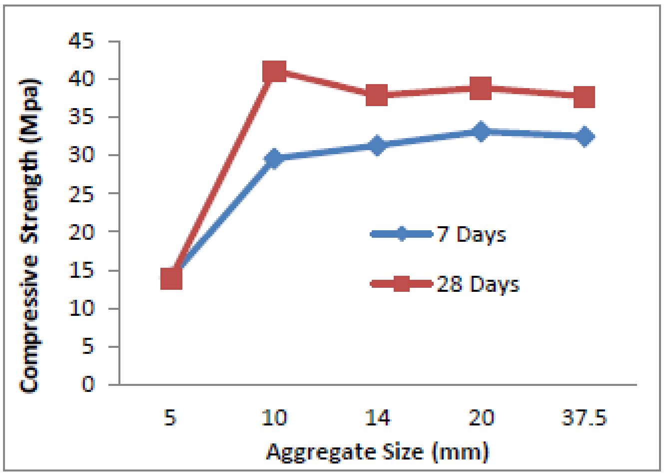

Figure 2. Variation of Compressive strength (Poon et al., 2004)

3.2.2Water Absorption

Rao et al., (2005) studied that the water absorption in RA ranges from 3 to 12% for the course and the fine fractions with the actual value depending upon the type of concrete used for producing the aggregate. It may be noted that this value is much higher than that of the natural aggregates whose absorption is about 0.5–1%. The high porosity of the recycled aggregates can mainly be attributed to the residue of mortar adhering to the original aggregate. This, in fact, also affects the workability and other properties of the new concrete mix as discussed separately.

Absorption is the moisture measured when every pore is saturated by water, but when the surface is dry. The water absorption rate can influence both fresh and hardened concrete properties (Etxeberria M; 2007). Concrete made of recycled aggregate had less compressive strength and resistance to freezing and thawing than concrete made of natural aggregate (Tam VWY 2008). However, the absorption capacity of aggregate also affects the workability of concrete (Rao A,2002).The absorption capacity of aggregates depends either upon a consistent degree of particle porosity or represents an average value for a mixture of variously high and low absorption materials (Tam VWY, 2008).The variation of water absorption is shown in Figure 3. Normally, recycled aggregate is more absorptive than natural aggregate. Due to its high absorption capacity, recycled coarse aggregate must be wet before its use in making concrete. If the recycled coarse aggregate is not humid, it absorbs water from the paste, thus losing both its workability in the fresh concrete, and also the control of the effective w/c ratio in the paste. In consequence, the increased absorption of recycled aggregates means that concrete made with recycled coarse aggregate and natural sand typically needs 5% more water than conventional concrete in order to obtain the same workability(Padmini AK, 2009).

Generally, NA has water absorption values between 0.5% and 1.5%, which is normally omitted for most concrete applications. However, more precautions must be taken when using RA because of their greater porosity. RA will almost always exhibit higher WA values than NA.

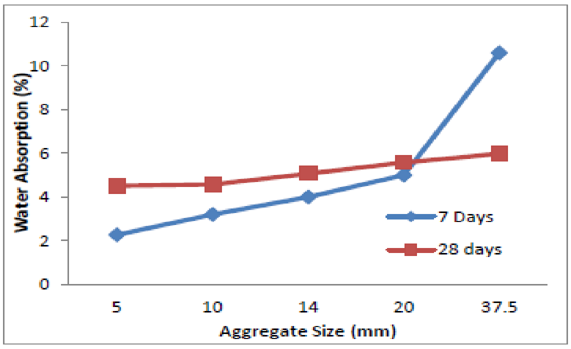

Figure 3. Variation of Water Absorption (Tam VWY, 2008)

3.2.3 Density

Density is an essential property for concrete mix design. It is also crucial for calculating the concrete volume produced from a certain mass of materials. The particle density of an aggregate is the ratio between the mass of the particle material and the volume occupied by the individual particles. The lower the density of the aggregate, the higher its cement mortar content will be. Consequently, the density of the recycled aggregate is significantly lower than that of natural aggregate. Lower particle density in the aggregate increases its absorption capacity and reduces its strength. As a result, a greater amount of water and cement is required, and this makes it more difficult to achieve the required levels of concrete strength and durability (Tam VWY 2008). Different recommendations give limits for this parameter. For example, the Riles recommendations, which provide specifications for concrete made from recycled aggregates, divide recycled aggregates into three categories (Types I–III); Type I pertains to aggregates primarily from masonry rubble, and which, according to these recommendations, should have a minimum dry particle density of 1500 kg/m^3.

4. Conclusion

This paper has demonstrated the significant potential for growth of RCA as an appropriate solution to the anticipated increased world-wide construction activity. There are few (if any) applications issues related to use of RCA. New standards are easing its use in higher value applications. Nonetheless, this is very much limited to few countries and the message has to travel round the world to make a meaningful difference to the suitable use of RCA in concrete. Practice has to catch up with the sound knowledge of use of RCA, which needs to be capable of being packaged in a manner that is easily workable and help to gain confidence on use of RCA.

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