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Recycled Concrete Aggregates

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ABSTRACT

This paper describes the introduction and production of recycled concrete aggregates and its various applications in the construction industry. Reduced extraction of raw materials, reduced transportation cost, improved profits, reduced environmental impact and fast-depleting reserves of conventional natural aggregates has necessitated the use of recycling, in order to be able to conserve conventional natural aggregate. In this study various physical and mechanical properties of recycled concrete aggregates were examined. Recycled concrete aggregates are different from natural aggregates and concrete made from them has specific properties. The percentages of recycled concrete aggregates were varied and it was observed that properties such as compressive strength showed a decrease of up to 10% as the percentage of recycled concrete aggregates increased. Water absorption of recycled aggregates was found to be greater than natural aggregates, and this needs to be compensated during mix design.

Introduction

Concrete is globally the most widely used material in the construction industry. Basically, concrete is a manufactured product consisting of cement, aggregates, water and admixture. The composition of aggregates forms a major portion of the mixture consisting of sand, crushed stones and gravel which are inert granular materials. Construction aggregates make up more than 80 percent of the total aggregate market and are used mainly for building constructions and pavements. The word concrete comes from the Latin word ‘‘concretus’’ (meaning compact or condensed), the perfect passive participle of ‘‘concrescer’’, from the words ‘‘con’’ (togffpether) and ‘‘crescere’’ .

With the demand for land increasing day by day, the locations, capacity and width of the land that can receive waste materials are becoming limited. Added to it, the cost of transportationmakes disposal a major problem.

Hence the use of recycled aggregate from construction and demolition waste (C&D waste) in concrete is gaining momentum these days. Recycled aggregate concrete may become the need of the day in the years to come.

PAST STUDIES ABOUT RECYCLED CONCRETE AGGREGATES

1. JianzhuangXiaoa et al concluded in 2004 stated [3] that the compressive strength of recycled aggregate concrete generally decrease with increasing recycled aggregate

contents. For a recycled aggregate replacement percentage equals 100%, the elastic modulus is reduced by 45%.

2. Nelson, Shing Chai NGO in 2004[4] stated that the workability was good and can be satisfactorily handled for 0% recycled aggregate to 80% recycled aggregate and with more percentage replacement of recycled aggregate used in the concrete specimen, the percentage of tensile strength remained are gradually decreasing.
3. . Concrete made with recycled aggregate produced from construction and demolition waste has a compressive strength (28days) about 27% - 30% less than the strength of the concrete made with natural aggregates[5].
4. Concrete results showed that 25MP and 30MP strength can be reached using recycled aggregate as a coarse material. Using more than 35% of fine recycled aggregate causes an obvious weakness in the concrete strength.
5. Concrete made with recycled aggregates has a compressive strength about 22%-32% less than the strength of the concrete made with natural aggregates
6. The studies on the production and behavior of RAC were carried out in China about 15 years ago following the experiences in Europe and Japan [3, 4]. Since then, especially after the publication of a comprehensive review report by the first author of this paper [5], the benefits of RAC and the significance of this kind of work have been recognized by more and more experts and engineers in China. In the past 10 years, over 30 universities and institutes have been engaged in the active studies and developments on RAC, including the research group led by the first author at Tongji University in Shanghai. The Committee of Recycled Aggregate Concrete in China has also been setup and chaired by the first author. Up to now, numerous experimental studies have been carried out to investigate the material and physical properties of RCA, physical and mechanical properties of RCA, mix-proportion design of RAC, as well as the applications of RAC in engineering practices.

PROPERTIES OF RECYCLED CONCRETE AGGREGATES

1.Composition

Recycled aggregates are defined as aggregates obtained from the treatment of inorganic material which has been previously used in construction (159). The raw material is the waste material generated during the construction and demolition processes. Regarding the particular case of recycled concrete aggregate, this is obtained from the recycling process of concrete waste material. Therefore, the recycled concrete aggregates are mainly made of natural aggregate and adhered cement mortar. However, it may incorporate impurities and contaminants, which have a negative influence on the properties of the final recycled concrete (149). These impurities can be very diverse, such as plastic, wood, gypsum, bricks, ceramics, organic material, asphalt, aluminium.

2.Adhered mortar

The main differences between recycled concrete aggregate and natural aggregate are due to the presence of adhered cement mortar (110). This new material makes the aggregate density lower and the water absorption and Los Angeles coefficient higher, which means lower fragmentation resistance. Consequently, the quality and quantity of adhered mortar is one of

the key factors controlling the quality of recycled concrete aggregates and, indeed, the performance of recycled concrete (170). It is well known that the quality and quantity of adhered mortar is influenced by the quality of the original or parent concrete, production treatment designed in production plants and size fraction of the aggregates.

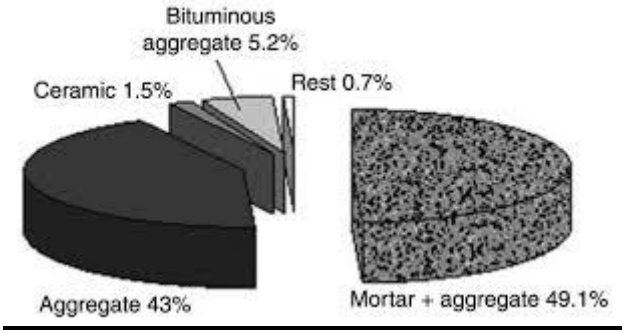

Fig.1 Recycled concrete aggregates composition

3.Shape and particle size distribution

Recycled aggregate grading is directly linked to the crushing process applied to the original concrete waste (38). Furthermore, this process is restricted bythe grading curves set out by countries in their regulations (159). If a grain size distribution analysis of natural and recycled aggregates is carried out, a different pattern of behaviour is observed for coarse and fine aggregates. The grain size distribution of recycled coarse aggregate does not differ appreciably from natural coarse aggregates. Hence, the recycled aggregate fineness modulus undergoes small variations for the same maximum aggregate size, depending mainly on the crushing process used and the original concrete quality (160). However, the recycled fine aggregate grading generally shows thicker size fractions than conventional fine aggregate. Debieb et al. (40) even points out that recycled sand consists mainly of gravel and a small quantity of medium-sized sand. Seventy-one different datasets were considered in the database. The fineness modulus obtained from different authors vary in the range of 5.70 to 7.36 for maximum aggregate sizes between 10 and 25 mm, as shown on Figure 4, with an average value of 6.55. Due to the presence of attached mortar, the surface texture of the recycled coarse aggregates is found to be more porous and rough (10, 38 and 150) than that of the natural aggregate. Furthermore, it should be taken into account that recycled aggregate generates fines during its manipulation due to the production of small mortar particles. The presence of these fine particles in the recycled coarse aggregate may decrease the bond between the recycled aggregate and the new cement paste and increase the mixing water necessary to achieve fixed workability when the concrete is made (130).

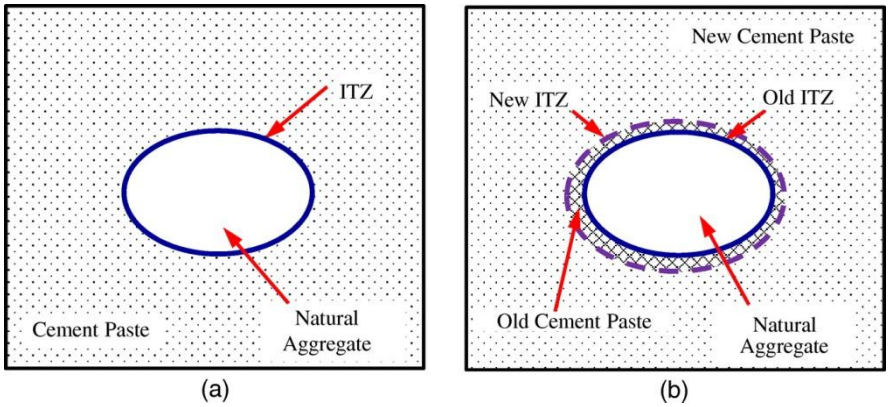

Fig.2 Recycled aggregate interface

4.Water absorption

The database has verified the usual statement that the water absorption of recycled aggregates is much higher than that of natural aggregates (3–154). The main reason for this difference is the presence of cement mortar that remains attached to the recycled aggregate particles. This cement mortar has higher porosity than the aggregates and therefore, recycled aggregates absorb more water than the conventional kind. The natural aggregate water absorption usually ranges between 0% and 4%. However, drawing an analysis from the database (two hundred and ninetynine datasets), the water absorption values obtained for recycled aggregates ranges from 1.65% to 13.1%, with an average value of 5.32%.

PRODUCTION OF RECYCLED CONCRETE AGGREGATES

1.Evaluation of Source Concrete. The 1st step in producing RCA from a concrete pavement is to determine the quality and overall properties of the source concrete. Records of the original concrete components, strength and durability can be useful in determining the potential applications for the RCA produced.

2.Pavement Preparation. If the RCA being produced is to be considered for use in a new concrete mixture, e-orts must be made to minimize the potential for introducing contaminants throughout the production process. Contaminants are generally of much less concern for RCA intended for use in subbase aggregate and ll applications. Potential contaminants in concrete pavement recycling typically include joint sealants, asphalt concrete shoulders and patching materials, reinforcing steel and dowel bars, and soils and foundation materials (NHI 1998). If possible, contaminants should be removed by an accepted method prior to the recycling process. Concrete pavements with asphalt concrete patches and overlays can be processed to produce RCA, but it generally is recommended that the two materials be recycled separately

3. Pavement Breaking and Removal The main purpose of pavement breaking is to size the material for ease of handling and transporting to the crushing plant. The slabs are broken into pieces small enough to be lifted and transported easily. Although other breaking technologies are available, the most readily available equipment for this operation are “impact breakers”, which break the pavement by dropping or hurling a heavy mass onto the pavement

4.Removal of Embedded Steel. The removal of reinforcing steel, tiebars and dowel bars can occur during several phases of the recycling process, but typically is accomplished during the breaking and removal operation or following the primary and secondary crushing operations, where electromagnets often are used to pick steel from the conveyor belts.

CONCLUSIONS

1.The database has made it possible to analyse the different properties of recycled concrete aggregate (aggregate recycled from concrete waste), such asdensity, water absorption, Los Angeles coefficient, etc. Relationships between these properties and also between some of them and the compressive strength of recycled concrete have been established.
2.The main difference between natural aggregate and the recycled concrete aggregate is the adhered mortar. The presence of this material decreases with the number of crushing processes, the size fraction and the original waste quality.
3.The natural aggregate water absorption usually ranges between 0% and 4% while the recycled concrete aggregate value is between 1.65% and 13.10%. Again, the water absorption increases as the maximum aggregate size and density value decrease. Using this database it has been seen that recycled concrete coarse aggregate with water absorption values under 7% provides saturated surface dry density values over 2300 kg/m³.

FUTURE RECOMMENDATIONS

1. From past studies and results it is recommended that proper design mixes with different percentage of recycled concrete aggregates with natural aggregates should be prepared to achieve the adequate strength of the concrete and to reduce the consumption of NA.
2. By using RCA the burden of construction wastes can be reduced to a suitable extent.
3. A suitable code of practice for recycled concrete aggregates should be prepared in which strength parameters about RCA are described.

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