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SHORT COMMUNICATION

A short note on recycled concrete aggregate

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ABSTRACT

For any type of construction projects, concrete is one of the most important materials. But the continuous use of fresh concrete is not good for our environment. The demolition of a building may produce a huge amount of wastage products. If we can use this demolished concrete as recycled concrete instead of a certain amount of natural concrete, then we can save energy, cost, money and environment too. So, the exercise of recycled concrete aggregate protects the environment from different harmful effects and also considered as a cost effective material. This paper narrates the various productions and applications of recycled concrete aggregate in the construction industry. This paper also discusses the various properties of recycled aggregates and compares with the natural aggregates.

Keywords: Recycled Concrete Aggregates, Natural Aggregates, Recycled Concrete

1. INTRODUCTION

Bangladesh is considered as a developing and middle power country. Among the world, Bangladesh ranks 46th according to the GDP (Gross domestic product) and having a huge number of people in the small land [WIKIPEDIA: Economy of Bangladesh]. So, the amount

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of the requirements of the concrete for construction is very high. The main potential sources of natural aggregates are natural mountains, river bank gravel or boulders, clay brick chips and rocks. But if this destruction will be continued, our environment must be adversely affected in future. So, it is high time to use recycled concrete aggregate (RCA) in lieu of them. The Annihilated construction site is the great source of collection of RCA. And the rate of the number of demolishing construction in our country is very high. According to this reason, the recycled concrete aggregate can also be used in a world largely instead of fresh concrete aggregate. Recycling of concrete is very important because it protects the natural resources and reduces the disposal of demolition waste from old concrete. In many regions, RCA is considered as a more cost effective material than NA. In the world, the production rate of RCA is calculated at 2-3 billion tons per year. In the last ten years, 7.5-12.5 billion tons of demolished concrete will rise globally. On EU construction site, the rates of manufactured demolished wastes are 850 million tons per year where 31% is considered as a total waste production rate. And In the USA, demolished RCA productivity is very high (123 million per year) [1-2].

So, as a result, the environment is getting polluted day by day by producing such a huge demolishing waste. It must be treated as a great threat to our civilization. So, the recycling process of such demolished concrete can help us to solve many problems. Moreover, the demolished concrete waste will be cleared up by using recycled concrete aggregate. Recycling of demolished concrete can create an additional business opportunity and save money for local government and also other purchasers. So, for many reasons recycling of demolished concrete becoming popular day by day. So, the main objective of this study is to review the overall aspects of recycled concrete aggregate. And Tang et al. (2017) [3] inspected the seismic effect on recycled concrete-filled steel tube columns in small scales. He found that the RCA-filled steel tube columns even have an appreciably better lateral bearing capacity, better ductility and slightly lower energy dissipation ability. So, he suggested this to use it in seismic responsible areas. But further investigation should be needed in the fire performance of the RCA-filled steel tube columns, this is considered as a potential gap of research in the field of steel-concrete composite structure. The major properties of RCA and RCA concrete are also discussed in this paper. There are significant gaps in the current knowledge on RCA and RCA concrete. This paper finds these gaps and provides some recommendations for future research.

2. PRODUCTION OF RECYCLED AGGREGATE

Depending on the source, it could include removal of impurities such as steel, wood, plastic etc. So, recycled aggregate once we are trying to produce, it does not come as a pure rock.

1) Crushing of concrete pieces to below 300 mm to facilitate further processing.
2) A magnetic screen is used where the material is passed and the removal operation of iron and steel is occurred. So, the process of producing recycled aggregate is largely similar to that of producing natural aggregate or new aggregates except that a new aggregate; we do not have to be so particular about the moving inherently present impurities.

3) The Material is separated as per size requirement and finally washed.

3. CONTAMINANTS IN RECYCLED AGGREGATE

Presence of contaminants makes it difficult to maintain a consistent quality of concrete and efforts should be directed to keep the level of contamination at the lowest through appropriate quality control of the recycled aggregate itself. The properties of coarse and fine aggregates are interconnected to each other. If one is changed, the other is affected. The recycled aggregate has different contaminants which are being produced it is likely that the variation in the properties of the recycled aggregate is a lot more than we normally expect in the case of normal aggregate and that is what makes them marginal materials.

Bitumen: Found in RA made from rigid pavements with bituminous overlays. Reported reduction in strength of concrete and a reduction of 30% in strength have been reported due to the presence of 30% by volume of asphalt in RA [4]. It is possible to remove all asphalt which is adhering to a concrete aggregate, but that process will be more expensive.

Mortar: In aggregate from concrete, mortar cannot be easily removed from the surface, and this often leads to the degradation of the properties of the new concrete.

Organic matter: Many organic substances such as paper, wood, textile fabrics, joint seals and other polymeric materials are unstable in concrete when subjected to the effect of thawing, freezing, welting or drying. Organic clay or soil pollutes the demolished concrete. The clay is difficult to remove once incorporated into the material and clay materials could be deleterious.

Chlorides and sulphates: Presence of these and other salts in RA has a minor influence on the properties of plain concrete. But in reinforced concrete, steel corrosion is occurred by the existance of chlorides and sulphates. Sulphates may react with hydration products leading to excessive and undesirable expansion of hardened concrete in the damp condition.

4. APPLICATIONS OF RCA

The practice of RCA is increasing day by day and used in different purposes in many countries.

- Ready Mix Concrete: Ready mix concrete is used for commercial slab and residential slab; walk and curb residential street; foundation etc.
- RCA is used as an aggregate base course in the foundation for roadway pavement. And this layer is considered as a basic structural layer of roadway pavement.
- Landscape Materials, building or paving blocks, Retaining walls, pipe bedding, water feature, underpass abutment structures and erosion structures are considered as the important implementations of this.

5. DIFFERENT FEATURES OF RECYCLED AGGREGATE

The characteristics of recycled aggregate may vary with the natural aggregate which is found from nature. The main difference between the recycled aggregate and natural aggregate is the presence of cement mortar in recycled aggregate. Mortar porosity is such a kind of property which can influence the bulk density of aggregate. And in the recycled aggregate, having more old mortar cement which has a high porosity. So, the bulk density of recycled aggregate is lower than natural aggregate because of having more pervasive mortar. The aged mortar is liable to decrease the bulk density of recycled aggregate. So, the removal of aged mortar is urgently needed to overcome this. According to the experimental results, the bulk density of recycled aggregate is 10% lower than the natural aggregate.

Water holding capacity: Because of having high porosity, the water holding or absorption capacity is greater in recycled aggregate rather than natural aggregate. In recycled concrete aggregate, their presents two types of an interfacial transition zone. They exist in old cement mortar aggregate and newly mix aggregate. These are the main culprit for increasing the water absorption of RCA. But in NA, one interfacial transition zone exists. So, the ranges between the water absorption capacity of RA are 3.7 to 8.7% and NA is 0.8 to 3.7% [5]. And this affects the workability and durability of hardened concrete.

Thawing and Soundness/freezing: Naturally RA is not so sound and durable compared to the NA. From L.A. Abrasion test, the ranges of mass loss of RCA are 15 to 30% and NA is 20 to 45%. The losses of RA are inversely proportional to its particle sizes. The presence of cranks of mortar may create the loose bonding and fracturing activity of hardened RCA and this is the main reason for poor soundness of RA.

Size of Aggregate: At first, a recycled aggregate is collected from the demolished concrete waste. The removal of impurities and crushing are the main recycling process of recycled aggregate. An investigation showed that the size of 10 mm and 14 mm RA can give more strength in hardened recycled concrete with compared to 20 mm A. So, more investigation should be needed on the perfect cost-effective grading of RA which may acquire great strength in the hardened condition.

6. PROPERTIES OF FRESH RECYCLED AGGREGATE CONCRETE

Naturally RA has the smaller workability than NA with considering the same amount of water content. But when the amount of recycled coarse aggregate is crossed 50% in concrete, then the workability of this concrete is reduced. Having high water absorption capacity of recycled aggregate causes the bleeding when it reaches the saturated surface dry condition (SSD). And this has badly affected the workability and strength of concrete.

Some researchers have conducted to overcome such situation. If 25% fly ash is replaced by cement, then the concrete strength is increased and bleeding is reduced. The relationship between the amount of recycled aggregate and slump value are proportional to each other. This may happen due to the initial free water. RAC (Recycled aggregate concrete) has higher value of air content than NAC. This occurred because of having the high porosity of recycled aggregate. The bulk density of concrete which is constituted of RA is 2150 kg/m3 and NA is

2400 kg/m3 [6]. The lower value of bulk density depends on the specific gravity of aggregate, size of aggregate and increased air content of concrete.

7. PROPERTIES OF HARDENED RCA

Tensile and flexure strength: In RAC, the relationship between the water and fineness modulus of fine aggregate is reversely proportional to each other. For low strength concrete mix design, uses of RA can give satisfactory strength. And the relationship between tensile strength and amount of RA is also adversely proportional to each other [7-9]. If supplementary materials are used in RAC, then the strength of RAC is also increased. And the tensile strength of RAC is less than 10% of NAC.

Compressive Strength: Naturally the compressive strength of NAC is higher than RAC. And concrete shows maximum compressive strength at the mixed of 0% RA. But 30-40% RA in concrete has gained satisfactory compressive strength. The relationship between the compressive strength and w/c ratio is inversely proportional to each other. Rao et al. commented that the relationship between the amount of RA and slump value is reversed to each other with a specific w/c ratio [10]. Katz also showed that at high water content the percentage up to 60% of RA can give satisfactory results of compressive strength. So, the compressive strength in concrete depends on the moisture content, w/c ratio, cement replacement ratio and percentage of RA [11-12].

Modulus of Elasticity: The relationship between the amount of recycled aggregate in concrete and compressive strength is inversely proportional to each other. At a specific amount of RA in concrete can increase the value of compressive strength. So, further investigations should be needed on that issue. Elastic modulus can reduce 45% of the increase of 100% use of RA in concrete. The High amount of RA and w/c ratio can reduce the elastic modulus of concrete.

Creep and Shrinkage: The shrinkage rate of recycled concrete is higher than natural concrete. And the shrinkage rate of RAC is 40% more than NAC. More investigations should be needed in that area. The combined effect of shrinkage and creep should be studied in hardened RAC.

Bond Strength: Bond strength of RAC is quite weaker than NAC. And more experimental data are needed in this area.

8. COMPARISON BETWEEN RCA & NA

It is seen that the water absorption capacity of RCA is high because of having two interfacial transition zones (the gap between the hydrated cement paste and coarse aggregate). So, more gaps are created in RAC and hold more water. So, for some reason, the dry density of RAC is less than the NAC. The shape of natural aggregate is smooth and round

but on the other hand, the shape of RA is angular. The specific gravity is also more in RA than NA.

9. FUTURE RECOMMENDATIONS

1) More research should be needed to find the proper mix proportion of recycled aggregate instead of natural aggregate to achieve the adequate strength.
2) The effect of the supplementary materials on RAC should be studied.
3) Additional experimental data are required for the combined effect of creep and shrinkage of hardened recycled concrete aggregate.
4) For recycling concrete aggregate, a suitable code of practice should be prepared carefully.
5) It is known that the RCA has the high water absorption capacity. So, it can be used in the area of permeable concrete pavement (it is also called Drainage concrete pavement) in order to prevent the water tightness related problem in the pavement. More research should be needed in this field. This is the ultimate concrete solution for surface and stormwater management.
6) More observation should be needed on the effect of RCA on the durability performance of concrete with respect to resistance to freezing and thawing, acid attack, bond strength and effect of seawater (Offshore engineering).
7) An assessment of the electrical resistivity and gas permeability of RCA concrete should be needed.
8) Segregation resistance of RCA concrete is also being studied.
9) More investigation should be needed on the effect of particle sizes of RCA on the properties of hardened RCA concrete.
10) By using RA, the behavior and strength of (PEC, FEC and CFT) columns should be studied. And the effect of seismic load and fire load are also being studied by RA in steel -concrete composite columns.

10. CONCLUDING REMARKS

a) The Recycled concrete aggregate has two interfacial transition zones, so, its water absorption capacity is high.
b) The water capturing capacity of RAC is very high.
c) By using RA in low strength and light weight of the structure, the waste management problem can also be solved.
d) The performance of RCA can be enhanced by mixing admixtures, pozzolanic materials and using new mixing techniques etc.

e) The RA is used in CFT columns, then the target strength will be achieved with minimum cost.

f) The strength properties of RCA concrete can be affected by the aggregate abrasion, impact and crushing value of RCA.

Though the demerits of recycled concrete aggregate are more, it has some merits too. More research should be needed to pick up these merits in order to apply recycled aggregate in many construction projects. This paper mirrors the overall pictorial view of recycled aggregate concrete. It is ensured to create public awareness in order to safely use of recycled concrete. More investigation is needed to create better mix proportion of recycled aggregate instead of natural aggregate in any construction project. And, specific instructions for using RA should be needed.

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