RECYCLING OF CONSTRUCTION MATERIALS FOR SUSTAINABILITY

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Abstract - In India, many talks are being heard about sustainable construction and researchers are taking up studies here and there on use of unconventional construction materials that are aimed in using waste materials. However, focused attention on sustainability of materials for construction is needed. Though the time is not yet ripe for forming such an association in India, it is time for everyone concerned in the topic to start thinking about such a move

KEY WORDS: Recycling Of Concrete, Recycled Concrete Aggregate, How Concrete Is Recycled

INTRODUCTION
Concrete recycling is becoming an increasingly popular way to utilize aggregate left behind when structures or roadways are demolished. In the past, this rubble was disposed off in landfills, but with more attention being paid to environmental concerns, concrete recycling allows reuse of the rubble while also keeping construction costs down.

LITERATURE REVIEW
- Markets for recycled concrete aggregate
  - Aggregate Base Course, or the untreated aggregates used as foundation for roadway pavement, is the underlying layer which forms a structural foundation for paving. A cross-section of pavement would show dirt, or subgrade, as the lowest of three levels, with aggregate base course at the center and pavement (whether concrete or asphalt) at the surface. This is the major market in the India and can be mastered as the simplest and easiest use of recycled concrete. To date, it is also the most owner-accepted use of recycled concrete by Departments of Transportation. Recycled asphalt is also accepted as a usable aggregate base course or road base. Ready Mix Concrete consists of a blend of cement, sand and water. This market is in its infancy stage with few recyclers attempting this re-use strategy although confidence is gaining through the Built Green program. Above all, the recycled concrete aggregate producer must make a quality product and have secured a willing and progressive ready mix producer who already has something that works. The ready mix producer must then, in turn, make a quality end product. Uses to date are: residential slab and foundation; walk and curb; residential street; commercial slab and foundation; and concrete paving per aggregate approval.

Soil Stabilization is the incorporation of recycled aggregate, lime, or fly ash into marginal quality sub grade material used to enhance the load bearing capacity of that sub grade. The process changes the water susceptibility of sub grade thereby stabilizing the soil/sub grade. Many times concrete aggregate can be found and reused on the same project for this purpose. Pipe Bedding: Recycled concrete can serve as a stable bed or firm foundation in which to lay underground utilities. In this scenario, recycled concrete aggregate serves as a replacement of virgin aggregate. Originally, local municipalities developed specifications based on what is readily available in the area. This use of recycled concrete aggregate is only economical if there is savings in the yield and transportation costs.

Landscape Materials: Recycled concrete can be used in various landscape settings. Sized concrete rubble can serve as landscape feature; an attractive support that offers different architectural texture and color while contributing to Built Green architecture. To date, recycled concrete aggregate has been used as boulder/stacked rock walls, underpass abutment structures, erosion structures, water features, retaining walls, Value engineering benefits
- Produce specification sized recycled aggregates at own location.
- Avoid haul-off costs and landfill disposal fees.
- Eliminate the expense of aggregate material imports and expors.
- Increase project efficiency and improve job cost - recycled concrete aggregates yield more volume by weight (up to 15%).

- Minimize impact to community infrastructure by reducing import and export trucking.

INDIAN STATUS
There is high demand of infrastructural facilities like houses, hospitals, roads etc. in India and large quantities of construction materials for creating these facilities are needed. The planning Commission allocated approximately 50% of capital outlay for infrastructure development in successive 10th & 11th five year plans. Rapid infrastructural development such highways, airports etc. and growing demand for housing has led to scarcity & rise in cost of construction materials. Most of waste materials produced by demolished structures disposed off by dumping them as land fill. Dumping of wastes on land is causing shortage of dumping place in urban areas. Therefore, it is necessary to start recycling and re-use of demolition concrete waste to save environment, cost and energy.

Central Pollution Control Board has estimated current quantum of solid waste generation in India to the tune of 48 million tons per annum out of which, waste from construction industry only accounts for more than 25%. Management of such high quantum of waste puts enormous pressure on solid waste management system.

In view of significant role of recycled construction material and technology in the development of urban infrastructure, Technology Information, Forecasting and Assessment Council (TIFAC, Department of science and technology, GOVT. OF INDIA) has conducted a technomarket survey on ‘Utilization of Waste from Construction Industry’ targeting housing/building and road segment. The total quantum of waste from construction industry is estimated to be 12 to 14.7 million tons per annum out of which 7-8 million tons are concrete and brick waste. According to findings of survey, 70% of the respondent have given the reason for not adopting recycling of waste from Construction Industry is “Not aware of the recycling techniques” while remaining 30% have indicated that they are not even aware of recycling possibilities. Further, the user agencies/ industries pointed out that presently, the BIS and other codal provisions do not provide the specifications for use of recycled product in construction. The properties of RCA will further ensure the sustainable development of buildings in mid nineties with the aim of developing techniques/methodologies for use recycled aggregate concrete in construction. The experimental investigations were carried out in Mat Science laboratory and Institutes around Delhi/GDB to evaluate the mechanical properties and durability parameters of recycled aggregate concrete made with recycled coarse aggregate collected from different sources. Also, the suitability in construction of buildings has been studied.

The properties of RAC has been established and demonstrated through several experimental and field projects successfully. It has been concluded that RCA can be readily used in construction of low rise buildings, concrete paving blocks & tiles, flooring, retaining walls, approach lanes, sewerage structures, sub base course of pavement, drainage layer in highways, dry lean concrete (DLC) etc. in Indian scenario. Use of RCA will further ensure the sustainable development of society with savings in natural resources, materials and energy.

How Concrete Is Recycled
Products are high quality aggregate, processed in steps with time and effort involved in crushing, pre-sizing, sorting, screening and contaminant elimination. The denominator is to start with clean, quality rubble in order to meet design criteria easily and ultimately yield a quality product that will go into end use.

Crushing and screening systems start with primary jaws, cones and/or large impactors taking rubble from 30 inches to 4 feet. A secondary cone or impactor may or may not need to be run, and then primary and secondary screens may or may not be used, depending upon the project, the equipment used and the final product desired. A scalping screen will remove dirt and foreign particles. A fine harp deck screen will remove fine material from coarse aggregate.

Further cleaning is necessary to ensure the recycled concrete product is free of dirt, clay, wood, plastic and organic materials. This is done by water floatation, hand picking, air separators, and electromagnetic separators.
Occasionally asphalt overlay or patch is found. A mixture of asphalt and concrete is not recommended but small patches are not detrimental.

The more care that is put into the quality, the better will be the product received. With sound quality control and screening one can produce material without having to wash it as with virgin aggregate, which may be laden with clay and silt.

Recycle Plants
The choice of one or several types of these recycle plants will be determined by the project. For example, is the project a redevelopment? Is there demolition onsite? Is the site a recycle center? Rest assured there is a recycle plant to fit the project.

Mobile Recycling Plant: This type of recycling plant can be moved to various locations economically. Track-mounted plants allow superior on-site mobility. Portable Recycling Plant: Choosing the right crusher for a particular concrete recycling project depends on several factors to be successful/profitable. What goes into the crusher, what is used to feed it (loader or hoe) and what specification final product is needed determines the size, type, and capacity of the unit / units. Preparation: How much are you willing spend to prepare the material before it is ready to crush? This will determine the maximum feed size the crusher will be fed and how much steel/rebar/wood/dirt needs' to be removed prior to crushing. This is typically done with hammers, hydraulic crunchers, and pre-screening. Magnets may be used to remove the loose steel.

Type Of Crushers: Jaw Crushers - Jaws compress the concrete between a stationary and moveable plate. Concrete is reduced in size as it travels down the length of the wedge between the two plates. Jaws are used as primary crushers and typically produce a 4” to 8” minus product usually used as fill. Impact Crushers - Impactors have a spinning rotor with bars or hammers that fling the concrete into a solid plate, several plates, or rods. Impactors can be used as primary, secondary, and even tertiary crushers and produce a product typically 2” minus used as base material in some parts of the country. Cone Crushers - Cones are also compression type machines with the concrete being compressed between two cone-shaped plates. Concrete feed to a cone is typically 6” minus as they are used mostly as secondary crushers behind a Jaw or Impact Primary. Cones typically produce products of 1-1/2” minus.

All of the above crusher types are available in Portable, Mobile, and Stationary configurations. Portable crushers are mounted on rubber-tired chassis and towed to the site by truck. On site, they are moved by loaders or tugs. Mobile crushers are carried to the site by truck and trailer and have their own onboard drive system typically track driven. These units move easily on sites where several moves are required. Stationary crushers are just that they are permanently fixed to the ground. Typically used in a recycling yard where all material is trucked to the site.

Case Study: "Recycled Concrete Aggregate Ready Mix Used in Structural Applications"
In 2008, ReCrete Materials, Inc of Arvada, Colorado provided approximately 7,900 cubic yards of ready mixed concrete containing recycled concrete aggregate for use in foundations and tilt-up panels at the Enterprise Park at Stapleton project in Denver. In a unique effort, Etkin Johnson Group, general contractor Murray and Stafford, Inc., concrete contractor CAL Construction, Inc. and Forest City Development utilized the recycled mix designs for their office and industrial development, which is located within the borders of what was once Denver’s Stapleton International Airport.

ReCrete Materials, Inc utilized 2,305 tons or just over 4.6 million pounds of recycled aggregates from the runways of the former airport in the construction of three high-end office/warehouse buildings. The 2,200 cubic yards used in the foundations contained approximately 620 tons (1,240,000 lbs.) of recycled aggregate and 115 tons (230,000 lbs.) of flyash. Total recycled weight in the foundations equaled 735 tons or 1,470,000 lbs. The 5,700 cubic yards utilized in the tilt-up panels contained approximately 1,570 tons (3,140,000 lbs.) of recycled aggregate (no flyash was used in this mix design). Flyash was not allowed in the tilt-up panel mix design, therefore only the recycled aggregate qualifies as a recycled product.

According to the Tilt-Up Concrete Association, the 1,570 tons of recycled concrete utilized in the tilt-up panel mix design on this project is the largest use of recycled concrete in a tilt-up application on record. Tilt-Up Contractor, CAL Construction, Inc. of Denver noticed little, if any, difference in the recycled material, including the ability to pump and finish, and recorded higher end strengths than found in traditional mix designs.

The developer, Etkin Johnson Group, plans to seek LEED certification for this project, which includes three buildings with 441,000 square feet of office and industrial space within the Stapleton Redevelopment. Energy efficient, green building design will be incorporated throughout. The decision to use recycled concrete for this project was based on several factors:
- The material was readily available at nominal additional costs.
- The end product met all quality standards.
- The use of recycled material allowed the concrete admixtures to be tailored to the needs of each part of the project.
- The use of recycled aggregates had positive environmental impacts.
- The proximity of the recycled material, in this case, offered additional points toward LEED certification as did the fact that recycled concrete aggregate qualifies for both pre and post-consumer LEED points (while flyash does not).

According to ReCrete Materials, Inc., advantages to using a recycled mix designs are:
- Reduces plastic shrinkage cracking and reduces initial set times.
- Higher 7 day and 28 day strengths.
- Improved finishability
- Diversion of useable concrete aggregate from the waste stream.
- Reduces number of truck trips from distant quarries.

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* Department of Transportation’s design specification

**Other Properties of Recycled Aggregates**
- Recycled aggregate yields up to 15% more volume by weight.
- Recycled aggregates are typically more angular and multifaceted than virgin aggregates.

ReCrete Materials, Inc. focuses on the utilization of recycled concrete in new ready mix applications while also providing virgin mix designs. ReCrete projects to date have been private, public, industrial and commercial with a client list that includes City and County of Denver, City of Thornton, City of Arvada, the Town of Golden and numerous residential and commercial/industrial construction firms in the Denver metro area.

**Conclusion**
The Recycle Concrete Aggregate can be beneficiated by crushing and screening to acceptable limits. The beneficiated recycle Concrete Aggregate has great potential for used in concrete and asphalt products with better performance over comparable virgin aggregates. Recycled aggregates are lighter weight per unit of volume, which means less weight per cubic yard, resulting in reduced material costs, haul costs, and overall project costs.