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SUSTAINABLE HANDLING OF CONSTRUCTION AND DEMOLITION (C & D) WASTE

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ABSTRACT

Development as a standalone feature has got no status, unless it is sustainable. Development may include active actions in various sectors like medical field, information technology, education etc. But, one field that is an inherent part of all is the construction sector. With the development of society and for the development of society at all fronts, construction activities are seen everywhere. Along with the construction activities, the demolitions of existing structures, which have either outlived their service life or otherwise needing replacement, have to be demolished. It is estimated that the construction industry in India generates about 10-12 million T of waste annually. The waste generation in Delhi itself is estimated to be around 5000 T per day. Thus a need is there to find solution for its sustainable disposable. Dumping of C&D waste is not only unauthorized, but also anti-environmental. It is a huge challenge to the mankind to find sustainable solutions for safe and secure reuse or recycling, so that nothing is required to be disposed or say dumping in an unauthorized manner. There is also a huge demand for natural aggregates in the construction sector with a significant gap in its demand and supply, which can also be reduced marginally by the recycling of construction and demolition waste. Proper handling, storage and treatment of C&D waste not only prevent degradation of Mother Earth, but also have significant impact on sustainability by way of reducing the use of natural resources. The paper covers various issues related to the reusing and recycling of C&D waste, required regulatory mechanism and procedures to be followed for achieving the aim with an ulterior motive of Environmental sustainability.

Keywords: Construction & demolition, Reuse, Recycling, Technology, Equipment.

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Contribution/ Originality

This study is one of very few studies, which have investigated into the effective methods and appropriate tools to carry out the demolition of existing structures so that the debris can be put into the reuse or recycling operations, getting useful products and also save Mother Earth from unsustainable degradation.

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1. INTRODUCTION

Our Society is growing in all sectors like creation of more medical facilities, more education facilities, more industries, more housing etc. Every growth involves heavy construction activities and the quantum is never such before in past. Construction activities and demolition activities are like sightseeing for a tourism industry. Both are going hand in hand. Whereas construction is due to rebuilding of old structures or new structures, demolition is growing due to old structures needs replacement with time and growing needs of the society. When the structures were created long back, the population was lesser and also the need of dwelling units was proportionately much lesser. Therefore lavish sized structures were created with more in area and lesser in numbers. Now, need is to create more number of units in the same land coverage for a better satisfaction of large sized population. When horizontal expansion is no more available, this is possible by reconstructing the house with vertical expansion and creating more number of such dwelling units. All such activities are generating huge amount of waste, called the Construction and Demolition waste. Disposal of such debris in a safe environment is a big challenge for the builders, developers and owners. When on one hand the disposal of debris is a challenge, then on the other hand there is an acute shortage of naturally available aggregates for construction of buildings. Reduction of this demand is possible only with the reusing or recycling of waste generated from the construction activities. Hence, the construction sector must accept the use of C& D waste wherever feasible. This will also lead to a little saving in virgin raw material, but significantly contribute towards the reduction in waste disposal.

2. REUSING & RECYCLING: 2 PILLARS OF WASTE STREAM UTILIZATION (Dhir and Paine, 2010; Mullick, 2012)

2.1. Reusing of C& D Waste

Reusing of construction and Demolition waste is different from Recycling. It does not require any further processing to convert into a useful product. The items which are usable directly are screened out from the debris and put into the possible use without further processing or the application of any further energy for conversion into the useful product. For example, full bricks can be screened out of the demolition debris and used as a partition wall in a building. Otherwise same would have been converted into smaller pieces for using it as an aggregate or brick bats for plinth protection etc. Thus reusing a waste item is a better contribution to the environment as it is saved from further impacts due to recycling activities.

Since the reusing of C&D waste is always more advantageous, it is essential that to have more and more reusable materials in debris. This is possible, if sufficient precautions are taken while a building is demolished. There should be an engineered deconstruction plan instead of just converting the standing structure into debris within minutes. Useful products like doors and windows, bricks, reinforcement, from RCC components, structural steel can be taken out with little extra efforts and put into reuse without much processing.

2.2. Recycling of C& D Waste

Once the waste generated from construction and demolition activities has been segregated and reusable items are taken out, the leftover is available for further processing i.e. recycling into next useful stage. Recycling of this waste into useful products to extend the service to environment is a challenge. If we see the world wide, there is enough scope of recycling of such a waste, but at present, in India, the recycling of Construction and Demolition waste has started now only and we have to go miles in this direction. In New Delhi, only one pilot plant is functioning at Burari in North Delhi, but it requires many such plants to fulfill the needs in Delhi after seeing the recycling potential of waste generated daily in New Delhi. About 5000 MT of recyclable waste is generated daily in New Delhi.

2.3. Concept, Education and Sensitization

Since the concept of C& D waste management is new, it is essentially required to spread the education and sensitize the Engineers as well as Developers in real Estate. Unless public support is there, the purpose of actual and effective recycling and promoting the use of recycled products cannot be achieved. It is essentially required to spread the concept and spread the education in this field in order to sensitize all the stakeholders for sustainable promotion of C& D waste reusing and recycling. The present mindset of public and their attitude towards the waste generated from construction and demolition sites is required to be changed. It is required to sensitize not only the Engineers and stack holders, but also the regulatory authorities in construction industry. One must appreciate the potential of reusing and recycling of C& D waste and technical aspects involved in this this along with the machinery required for demolition in Engineering manner as well as recycling in an Engineering manner. This will enhance the effective use of recycled materials and deployment of best practice for implementation, enforcement and achieving the aim with an ulterior motive of Environmental sustainability.

Recycling cost is influenced by transportation distance and amount of waste concrete to be recycled. CO_2 emission is influenced by transportation distance. It is important to minimize C&D waste generation and maximize reuse/recycling as the construction industry is consumer of tremendous amount of natural resources and energy as well as emitter of GHGs. Establishment of effective strategies and enactment of laws and regulations is essential to achieve this. In addition, provision of some incentives to users of the recycled products deems to be necessary to promote the use. It is essential to assess the life-cycle as it provides quantitative tool to assess environmental impact of C&D waste reuse/recycling.

3. ENGINEERING THE DEMOLITION OF BUILDINGS

In order to make the full use of C&D waste, it is essential that the building which is to be reconstructed is brought down in an Engineering manner so that the demolition waste does not become debris and left out for only disposal either on a dumping site or at most used for filling. Today, the demolition is not just a demolition which can be performed by any contractor in any

manner suitable as per his whims and fancies. It is a specialized Engineering which is as precise as construction of a new building, if one is sensitive towards the related Environmental issues, social issues and economics related with the demolition.3

3.1. Environmental Issues Related with Demolition

A building should be demolished in such a manner that maximum reusable components are safely dragged from the building using suitable extractors, chippers or any other suitable machinery. After the reusable components are segregated, recyclable components should be screened out and sent for recycling plant whether it is simply concrete or bricks or even metals or plastic components. Only the non-reusable and non-recyclable components are to be dumped in a safe and sound manner that to the approved dumping stations.

3.2. Social Issues

Safe and sound demolition of a building requires attention towards safety issues of the workers deployed in demolition. In the absence of appropriate machinery, it is going to put the labors on the job to a big risk and it will not amount to extraction of best results as afar as re-using and recycling is concerned. Many of the reusable / recyclable components will be lost as debris leftovers just with a fate of getting dumped below the earth. Another important factor to look into this aspect that skilled labor for demolition will not be always available. In such a situation it is the need to go for the most appropriate tools and machinery as partial replacement of the manpower.

3.3. Economic Issues

One must understand the limitation of the work output of a labor in any activity. When demotion is the activity, it is not only the efficiency of labor that counts, but the final productivity also matters. Appropriate tools and machinery will always result in maximum extraction of usable components and minimize the debris to be dumped. Thus it results in some contribution to the cost of construction and also reduced the cost of safe disposal of debris.

4. TOOLS AND MACHINERY

There are safe systems and supporting machinery available so that the building is brought down in the planned safe manner and also full potential of reuse of demolished material is made use of. Useful reusable materials like wooden materials including doors and windows, metallic beams or bricks can be taken out and put into the appropriate use without putting them into recycling system.

Fig-1. Wrecking Ball: Uncontrolled demolition

Fig-2. Mounted Hydraulic Breakers

It has been observed that in the past when safe and sound system equipped with appropriate machineries was not available, wrecking ball was used to crush the building wall. It was totally uncontrolled mechanism and many a times fatal accidents have occurred at work site due to lack of control on its movement, transfer of energy to the existing structure and throw of debris in all possible directions. In order to control such demolitions, hydraulic excavators with suitable attachments can make the task easier and better outcomes as far as reusable materials are concerned. It is always appreciated, if more and more reusable materials are taken out as it does not require any further energy for recycling. Such attachments may include hydraulic breakers, demolition processors, shears and demolition grapples. Before entering into any kind of demolition, number of components is at sight to remove and reuse most of them in the same building during its construction or for the maintenance purpose. Such materials having leftover depreciated value may include sanitary items like taps, copper pipes, GI pipes, conduits for taking electrical wires including all kinds of electric wires, telephone cables and components like electric lamps, bells, attachments for all kinds of electric gadgets etc.. All such materials can be safely extracted using simple machinery and tool kits, small shears and grapples on skid-steer loaders and excavators. A mini-excavator can work at any suitable angles for soft extraction of the items on a vertical surface, while for horizontal surface, a skid-steer can used for breaking up the harder surface. A skid steer equipped with a bucket is suitable for collecting up the useful materials and pushing the same out of the building under demolition.

4.1. Hydraulic Breakers

Hydraulic breakers are available in almost every size as per the need and type of demolition required. Such machinery is suitable for areas which other machineries or tools are not easily and safely accessible to carry out the demolition job. These machineries are suitable for breaking hard surface like RCC slabs and floorings.

4.2. Hydraulic Concrete Splitters

Fig-3. Hydraulic Concrete Splinters used for splitting the hard rock

These machineries are suitable for carry out the demolition RCC walls, concrete roads, deck slabs of bridges, industrial floorings or even splitting the rocks into pieces. For using these machines, initially holes are drilled into the surface at certain distances and the tool is pushed mechanically into the holes which split the structural components into smaller pieces.

4.3. Hydraulic Concrete Crushers

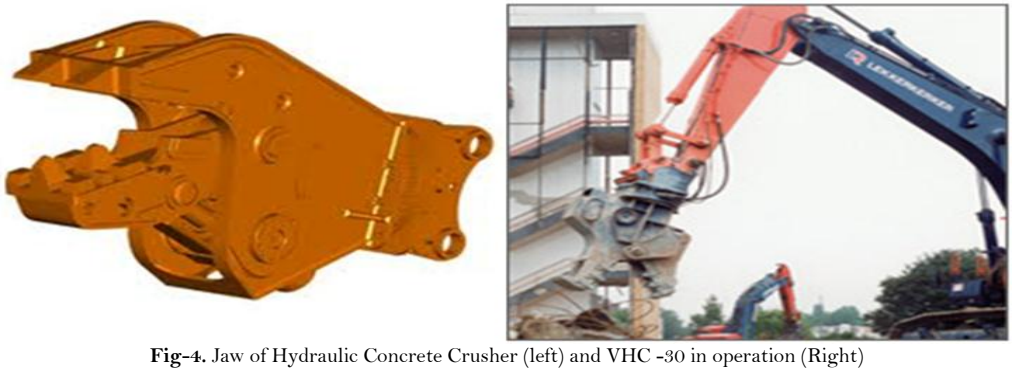

Fig-4. Jaw of Hydraulic Concrete Crusher (left) and VHC -30 in operation (Right)

Hydraulic concrete crusher uses the jaws to crush the structural components to be demolished. The jaw opens and closes under hydraulic control and this action helps in crushing the bigger sized components crushed into pieces. The pair of jaws is detachable and suitable types of jaws like cracking jaws, shear jaws or pulverizing jaws are attached as per the requirement. These crushers are mainly deployed as supplementary measures for finer crushing after carrying out the initial demolition by hammers, crushers, blasting, ball and crane, or sawing.

4.4. Long Reach Excavator

The system has a long reach boom which can be operated at non accessible locations at heights up to 20 m and horizontal coverage of 30 m. such machineries are used to pull down the high rise structure in a controlled fashion unlike the wrecking ball.

Fig-5. Komatsu PC450 with super long reach boom and drilling rig attachment.

Fig-6. Caterpillar CAT 385 C

4.5. Diamond Wire Saw

Diamond wire saws are more efficient than circular saws and can cut concrete of any thickness. The wire is wrapped around the concrete component to be cut into pieces with the help of diamond tools.

Fig-7. Diamond Wire Saw with Diamond Tools

4.6. Pulverizers

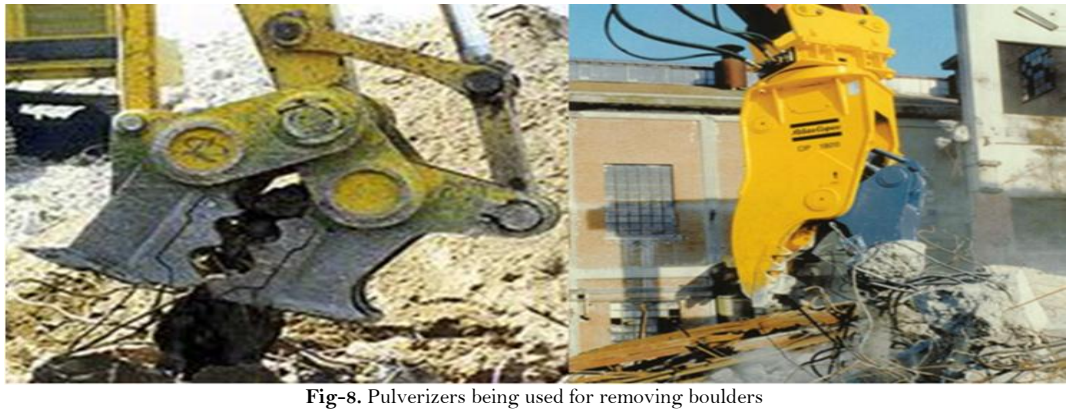

Fig-8. Pulverizers being used for removing boulders

Pulverizes or grapplers are widely used for removing large boulders and rubbles.

4.7. Rotary Drum Cutters

Rotary drum cutters are very versatile and are widely used for trenching hard stone, cutting pile heads and are put into use for construction as well as demolitions works as for cutting it can cut through concrete as well as bituminous road surfaces.

Fig-9. Rotary Drum Cutters in operation cutting concrete Roads

4.8. Expansive Demolition Agents

Fig-10. Expansive Demolition Agent being poured in predrilled holes (left) and crack developed and widened thereafter (Right)

The expansive demolition agent is a cementitious powder which is mixed in a bucket and poured into the pre-drilled holes. The mix expands after getting hardened leading to the development of hairline cracks in the concrete slab. These cracks widen further and breaking the

slab turned into pieces. Biggest advantage of such agents is the elimination of labor component from the job during the demolition process as no labor is further required after pouring the mix into the holes till the rubble is to be transported away. Other advantages are that there is no noise, no vibrations and no dust is produces in its action.

4.9. Pneumatic Hammer

Pneumatic hammers are mounted on lighter carriers and with the external air compressor are very useful in confined areas for drilling or chipping tough materials such as concrete and asphalt surfaces

Fig-11. Pneumatic Hammer mounted on carrier (left) and being used for drilling rock (Right)

4.10. Hand Held Concrete Cutter

Very handy equipment but heavy duty designed to quickly break away large, thick pieces of concrete. The benefits are limited dust, support a clear view at the rescue scene, no vibrations and prevent risk of secondary collapse.

Fig-12. Concrete Cutter in Hand cutting concrete

4.11. Modular Pile Cutters

Fig-13. Modular Pile Cutter (left) and cutting Pile Head (Right)

These versatile modular pile cutters enable you to hire the exact pile cutter to suit square or circular piles in the size and diameter of your choice. For square piles 200 – 500 mm and circular piles 200 – 900mm. Cutting piles and preparing ready for foundation work has never been more efficient.

5. REUSE AND RECYCLING POTENTIAL OF DIFFERENT C&D WASTE PRODUCTS (Noguchi, 2012; Bansal and Singh, 2014)

The amount of C&D wastes in India has been estimated to be 15 – 20 million T annually with the figure to go further high with the rapid development in infrastructure and exponential growth in real estate. Proportion of concrete is estimated as 23 to 35% of total waste. Considering 30 % percent of C&D wastes as concrete, and 40 % of the concrete as coarse aggregate, the total recycled concrete aggregate (RCA) per year in India can exceed 2 million T.

5.1. Concrete (Radonjanin *et al.*, 2012)

Concrete is primarily a composition of cement, coarse aggregates, fine aggregates and water, further processed by addition of industrial products/ by products for enhancing the strength. Engineers are mainly dependent on nature for obtaining the Coarse and Fine aggregates as well as water for the chemical reaction with cement. Scarcity is there for all these naturally occurring materials and need is there to explore alternative sources. Even for the water with required properties, shift is towards the use of waste water after due treatment. One of the alternative sources of coarse aggregates is recycled concrete aggregates (RCA) which are obtained from the processed Construction and Demolition (C&D) waste. During and after the demolition of any concrete structure, the demolished concrete waste is taken to a recycling plant and there crushed into the required sizes which is called the Recycled concrete aggregate (RCA).

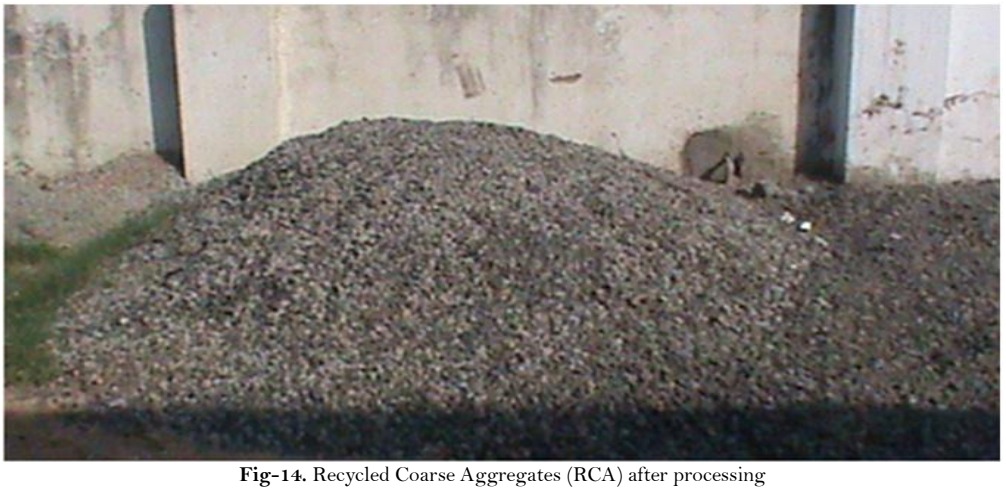

Fig-14. Recycled Coarse Aggregates (RCA) after processing

Sometimes, good sized precast element are also obtained during the demolition, which have a potential of being reused or otherwise, these are also crushed and converted into the recycled aggregates. Limitation is there in use of these recycled aggregates. The production of concrete in India is governed by BIS and IRC codes i.e. IS: 456, IS: 1343 or IRC: 112. All these codes allow the use of naturally occurring aggregates only conforming to IS: 383. To overcome these limitations, it is required to make a special provision of use of Recycled aggregates in combination with naturally occurring aggregates. Thus, use of recycled aggregates can be there with different value of their share by suitable replacing the component of naturally occurring aggregates. It will help out not only in meeting the situation where there is acute shortage of natural resources, but also a steep towards the sustainability. In our bye laws or environmental law, framing of rules will be required for the use of C&D waste. It can have a provision in Environment Protection act, 1986 or a separate act can be introduced independently. Guidelines are required to be framed for use of C&D waste. If we look at other countries like Norway, Japan and Korea, a major junk of demolition waste is recycled and is being used as a partial replacement of natural aggregates and concrete thus produced is being widely used in these countries.

5.2. Brick

Bricks are the important building material in the construction of residential as well as non – residential buildings. It is also a significant component of the total C&D waste on new residential construction sites. Its demand figures next to concrete as a building material. Bricks are largely treated as waste when broken or damaged from the brick production line or from construction site due to poor internal handling and excessive cutting (see Fig. 2). Brick is a maintenance-free component of the structure which is durable during the complete service life of the building. The high durability property of the brick makes it environmental friendly in the sense that after the demolition of the structure, it can be reused repeatedly and the left over volume which is non-reusable can be recycled for other beneficial purposes. Generally, a building is not required to be demolished due to deterioration in the Engineering properties of the bricks. It is for different

reason or different needs other reasons that the building has outlived its useful/economical service life and required to be replaced with new structure. During the demolition process itself, bricks obtained are stacked for next use in its original form after the removal of mortar which is chiseled out and make the brick ready for reuse or recycling, if not reusable.

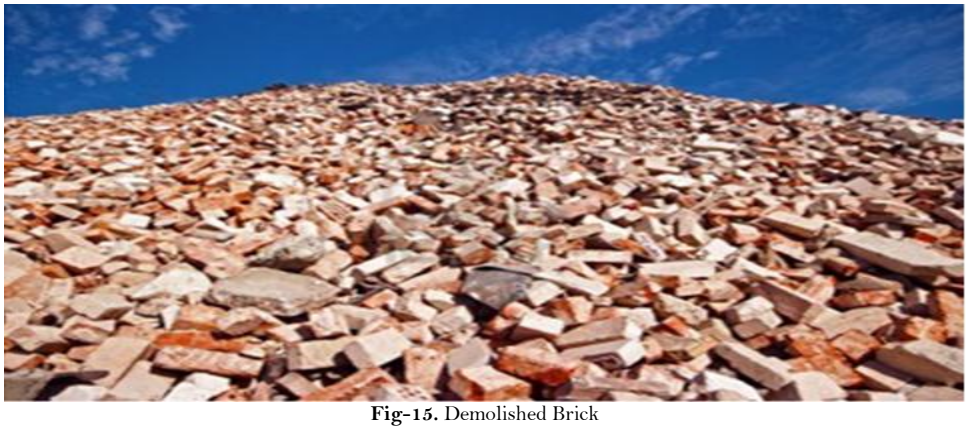

Fig-15. Demolished Brick

Bricks, after the removal of the stuck up mortar remain reusable for restoration or for new homes and projects. Recovered bricks can be used like a fresh lot of bricks without any further processing. These can also be laid on as brick pavers or for landscaping or any other artistic creations. Brick paved streets are aesthetically pleasing and rain water also percolates through the pavement. Also, a brick surface is cooler in hot months. These street advantages make bricks a good choice in driveways. Bricks on edge are also sometimes used as economical pavement solutions in smaller compounds. Bricks which cannot be reused directly can be disintegrated into smaller sized aggregates or brick chips to be used as construction materials. These recycled bricks products are strong and durable enough in comparison to the original brick. Bricks from demolition sites can be recycled as Road base and construction fill and also as light weight concrete.

Construction debris consisting of bricks can be recycled into brick aggregate through screening, crushing, re-screening and blending, which can then be used as pavement base material by proper mix proportions with cement and fly ash. Brick waste which are not suitable for recycling into the pavement base materials can be used in construction/land fill. Concrete prepared from crushed brick aggregate has good engineering and also better thermal properties but has greater shrinkage than ordinary concrete. Sometimes, during the manufacturing of bricks, due inadequate burning, or sometimes due to over burning, whole lot is turned into the production waste. Though this waste is different from construction and demolition waste, but it can also be recycled like C& D waste and can be suitable used for production of precast elements like paver blocks, curb stones, interlocking tiles by mixing with cement and using as a concrete mix.

5.3. Tiles

Generally, it is difficult to extract tiles from the walls in proper shape and size in order to find them suitable for reuse. It also depends upon the type of the tiles, their life span and the existing conditions. Seepage behind the walls due to leaking water pipes makes them totally non usable. Still tiles extracted from walls, even if these are broken pieces, provide an excellent opportunity to the artists /designers for making murals or other decorative master pieces. Broken tiles can also be used aggregate after crushing.

If the tiles can be extracted or removed from the wall in good shape and size, these are reused for the same purpose after the removal stuck up mortar and then glued with suitable adhesives available in market today. Creative items like artifacts, table tops, special effects in drive ways, pedestrian subways etc. can be smartly created by reusing for a wide variety of projects. Nek Chand's Rock Garden in Chandigarh, which is internationally renowned, is a perfect example of such reuses. The broken tiles can be further crushed into smaller sizes and can be a partial replacement of gravel and crushed stone in making concrete.

5.4. Timber

The waste timber is not only produced from the demolition of the building, but also from construction of wooden building wherein lot of timber waste is generated. Each source has its own system of recycling and reuse of recovered timber from the demolition of a building or the construction of a building. Whenever a building is decided to be dismantled, timber products like doors and windows are the items which are removed as first step and that too in original form. Timber products have a quality of a long service life which is much longer than the life of the building itself. Hence, in general such products unless eaten by the termites or damaged due to fire do not lose the Engineering properties for a long time and can be used multiple times and thus an environmentally friendly product.

Sometimes, the waste timber cannot be recovered in its original form or is not usable in same shape and size. Such timber can be recycled into new particleboard, medium density fiber boards, animal bedding or can also be used to make renewable energy. Timber used for recycling has to be free from any other demolition products like concrete, mortar, aggregates, sand, bricks, plastic, metals, tiles etc. Wood chips are produced from good quality wooden waste such as large size lumbers. Some of the particleboard producing companies and the pulp and paper producing companies are still using the recycled chip for their products. Chipped or shredded wood is also used as a sewage sludge bulking medium and other products lime pallets.

5.5. Metals

Amongst the metals, steel and Aluminum are the two major products obtained as waste during the construction as well during the demolition of a building. Structural steel obtained during the demolition of a steel structure or left over steel during the construction can be reused directly without much processing. The members can be resized as op the requirement and can be

reused directly. Aluminum scrap can be put into reuse by the solid bonding process. If a care is taken in initial stages i.e. during designing with a valid deconstruction plan, then the reusable scrape can be increased to a much greater extent like house hold appliances, without taking the routing the scrap through a foundry. Reusing a steel beam its existing form is better than re-melting it and rolling a new steel beam, i.e. the energy used to re-melt the beam is saved. Steel waste occurs during the construction and refurbishment of buildings and when they are ultimately demolished and the material becomes available for recycling. Waste from the manufacture of steel construction products can be easily collected and segregated for recycling. Steel generates almost nil wastage on the construction site. Waste steel which is reusable is equally good in durability criteria and the quality is also well maintained while making products like fire hydrants, steel furniture and also ecologically sustainable. As far as Aluminum is concerned, it is recyclable multiple times and is always on demand with the need to preserve the environment. Our raw materials vary considerably based on whether we are using primary or recycled aluminum. We must take into account the different sustainability impacts of sourcing primary aluminum from the mined substance bauxite, or recycled aluminum from either pre- or post-consumer sources. Recycling scrap aluminum requires very less energy in comparison to the energy requirement of new aluminum. Because aluminum is infinitely recyclable, it can be reused in applications vastly different from its previous purpose, and it can also be recast into its original form. These properties make aluminum an ideal material for use in premium applications, even after being recycled many times.

5.6. Plastic

Scrap or waste plastic recovered from demolition or construction site is reprocessed and transformed into the entirely different useful products. Typically a plastic is not recycled into the same type of plastic, and products made from recycled plastics are often not recyclable. When compared to other materials like glass and metals, plastic polymers require greater processing to be recycled. The most-often recycled plastic HDPE (high-density polyethylene) is reduced to plastic lumber, tables, roadside curbs, benches, truck cargo liners, stationery (e.g. rulers) and other durable plastic products and is usually in demand. Other application of recycled plastic is in the preparation of a road surface that includes recycled plastic: aggregate, bitumen (asphalt) with plastic that has been shredded and melted at a temperature below 220° C (428 °F) to avoid pollution. Such road surfaces are very durable and monsoon rain resistant.

5.7. Excavated Material

Excavated materials are many times contaminated and require special handling and disposal. It may include hazardous as well as non-hazardous material. Excavated contaminated material that can be re-used will be decontaminated prior to re-use, or if not suitable for re-use will be transported to appropriate treatment facilities or approved landfill sites. If the excavated materials are re-used as road fill base material, then cut and fill quantities should be balanced. It

will result in eliminating the off-site disposal. Excavated soils will be retained on site for re-use as backfill while hard rubble will be crushed and re-used on site. Unsuitable material for engineering fill can be used for landscaping.

5.8. Asbestos

Generally, asbestos is disposed as hazardous waste in landfill sites. The demolition of buildings containing large amounts of asbestos based materials have to be deconstructed piece by piece or the asbestos has to be removed carefully before the structure can be demolished. Asbestos can be recycled by transforming it into harmless silicate glass, porcelain stoneware tiles, porous single-fired wall tiles, and ceramic bricks. Current removal procedures require a completely sealed area, using vacuum to prevent any particles from escaping. Workers must wear heavy protective equipment. It is important to ensure that asbestos waste has been wetted and sealed in heavy-duty plastic prior to transportation to an approved landfill.

5.9. Asphalt Concrete

Demolished asphalt concrete can be utilized as aggregates for asphalt concrete. Also, the demolished asphalt concretes can be used for land fill.

6. SIMPLE GUIDELINES FOR RECYCLING OF DEMOLITION WASTE (Noguchi, 2012; Bansal and Singh, 2014)

The agencies responsible for generation of wastes should separate the generated wastes having potential for reuse/recycling. The Engineer-in-charge will select structure's type and materials that are suitable for reuse/recycling, use recycled aggregates, and ensure proper treatment of wastes generated from such development. The waste generation from construction should not only be minimized, but should also minimize the hazardous effect from the generated wastes.

6.1. Various Agencies (or Sub-Contractors)

Various agencies or sub-contractors to be involved are to be linked up with the steps in this process of C& D waste reuse and recycling. Some of such steps can be listed as waste collection and transportation, waste middle treatment i.e. receiving the waste, its segregation and further suitable comprehensive treatment before putting into the use. The cost for C&D waste separation, storage, treatment, reuse/recycling should be included in the Estimated Cost by the Engineer-in-charge while according Technical sanction and preparing tender documents.

There are important duties to be either assigned or as a dutiful contractor, he may be establishing himself like, he should establish step-by-step demolition plan. Contractor may establish treatment facility at site only. He should report expected amount of wastes by type and treatment plan at the beginning of construction. There should be effective utilization of recycled aggregates and Safe treatment of hazardous waste like asbestos.

6.2. C&D Waste Information on Web

All C&D waste information by contractor and by those involved in its treatment waste treatment companies are to be put on public domain in order to improve the rate of use of demolished concrete for e.g. application of recycled aggregates. Further to have a stronger data base of C&D waste, users reusing the C&D waste or recycled waste after treatment and processing can contribute a lot. This will help in substantial reduction on the amount of wastes and promotion of recycling or reusing the C&D waste.

6.3. Demolition Plan

It is required to adopt a systematic approach while demolishing a building in order to minimize the waste and its best use. A recommended approach can be to follow a sequence of segregation of household waste as first step followed by mechanical and electrical equipment, exterior and interior finishing materials, roof finishing and water-proofing materials, then structure as a last resort. Demolished C&D wastes need to be brought out of field immediately or temporarily stored in a designated area for the C&D wastes.

7. RECYCLING THE DEMOLISHED STRUCTURE

Once the structure is demolition as per the planned and in an Engineering manner using the most appropriate tools and machineries, the next step is the segregation of the products which can be put into reuse rather than recycling to useful aggregates or dumping in safe and approved manner.

Initially the useful products like bricks, steel frames, aluminum windows, wooden frames, doors and windows having reusing potential are segregated. There may be some material which are having good scrap value are also segregates before the debris is sent to the recycling plant. Even the reinforcement bars are taken out of RCC and may be put into the use in non-sensitive places like kitchen slabs, lintel beams.

For a proper and an efficient functioning of products in a recycling plant, it is essential that the debris brought to the plant is free from contamination by other types of undesired products like plastic, oils and paints. Use of appropriate equipment and machinery is essential in recycling process. Such equipment may be jaw crushers, magnetic separators, vibratory screens, washing equipment and can be deployed to segregate such scraps. Few of such machines are discussed in the following paras.

7.1. Portable Concrete Crushers

It crushes concrete into coarse / fine aggregate, which can then be recycled onsite. After pulling down the structure, the concrete slab is cut into smaller pieces to run through the crusher. The machine then grinds it into gravel-sized aggregates, which can be used for road compaction, structural fill, pipe bedding and other applications.

Fig-16. Portable concrete crushers in operation (left) and on mounted on carrier (right)

7.2. Track Mounted Mobile Recycling Crusher

Mobile crushing machine is usually utilized for contracting, quarrying and crushing work under mine. The mobile crusher can crush any types of rocks and minerals. The hydraulic driving track mounted mobile crushing machine are extensively utilized in road and bridge construction, urban construction, metallurgy, energy as well as other departments to do crushing and sieving perform.

7.3. Jaw Crushers

Jaw Crusher (or Rock crusher) is ideally suited for primary crushing of stones and is often used in mining, metallurgy, building materials, roads, railways.

Fig-17. Jaw Crusher in operation (Right)

7.4. Mobile Jaw Crushers

Mobile jaw crushers are suited for small to medium sized and have hydraulic adjustments for changing the size of finished products. The primary crushing applications ranges from hard and abrasive to mixed recycled materials.

Fig-18. Moblie Jaw Crusher

7.5. Cone Crushers

A cone crusher is generally used as a secondary crusher in a crushing circuit. Pre-crushed

Fig-19. Cone Crushers

Product (usually 3in minus depending on the cone crusher model) is fed through the top of the cone crusher and flows over the mantle. The vertical cone crusher drive shaft rotates the mantle eccentrically below the concave or bowl liner, squeezing the product and crushing it between the mantle and concave. Cone crushers are usually run on belt drives driven by an electric motor or diesel engine. Cone crushers are used extensively throughout the aggregate and mineral processing industry.

7.6. Mobile Cone Crushing Plant

The mobile cone crushing plant works on construction site. The mobile cone crushing plant can be shifted to crushing place directly as it will maneuver both in smooth and bumpy roads. It is compact to use and operations are simple. The mobile crushing plant fitted with generator, motor and control box on the trailer is suitable to work at outdoor with ease. The mobile crushing unit can function independently or can be used as a secondary unit for fine crushing. It can also work as a production line with the screening equipment according to the requirement of customers. Materials are delivered by belt conveyors, which is simple to operate and easy to maintain.

Fig-20. Mobile Cone Crushing Plant in operation

7.7. Horizontal Shaft Impactors

Horizontal Shaft Impactor (HSI) crushers break rock by impacting the rock with hammers that are fixed upon the outer edge of a spinning rotor. These machines are available in stationary, trailer mounted and crawler mounted configurations. They are used in recycling, hard rock and soft materials in wet and dry applications. Earlier it was used on soft materials and non abrasive materials, such as limestone, gypsum etc. They are used as primary and secondary crushers for size reduction. These Crushers offer operators a very high ratio of reduction and can accept larger feed sizes.

Fig-21. Horizontal Shaft Impactors in operation of breaking rock (Right)

7.8. Screens

Screens are equipment that is used for the separation of material into 2 - 6 different sized products. The material is separated by passing it through a vibrating 'screen box' which a number of different sized screens, or meshes, which the material falls through like a sieve.

Fig-22. Screening of materials

The material falls onto attached conveyors that stock the end products which can then be used in the building and construction industries. Screening equipment is either track or wheel

mounted to make them mobile. The equipment can move to the raw material rather than the expensive movement of the material to the screen.

7.9. Conveyors

Conveyors are designed to work in conjunction with the entire range of washing and screening equipment. Conveyors can be electrically or hydraulically driven. With the mobile range the ability to radial increases stockpile capacity and reduces on-site material handling.

Fig-23. Conveyor

7.10. De Watering Screens

Dewatering Screens are used for de-watering, de-sliming, de-gritting, rinsing, scrubbing and washing. Dewatering Screens offer multiple advantages for construction and specialty aggregates producers including a drier, drip-free product that other types of equipment cannot provide. There are many applications for Dewatering Screens in the aggregates market including dewatering after Sand Classifying Tanks and Fine Material Screw Washers, or use within a system such as the Recipe Sand Plant.

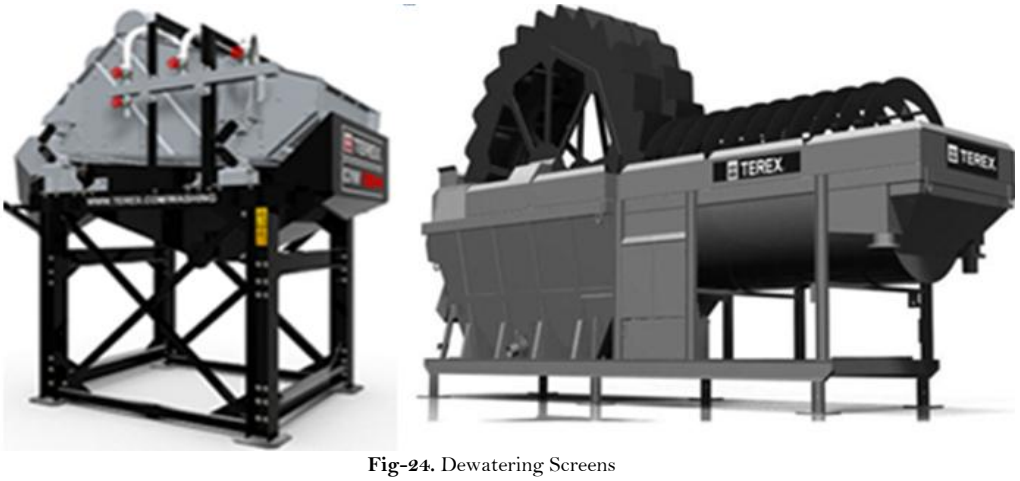

Fig-24. Dewatering Screens

7.11. Bucket wheel Screens

This mobile screen recovery screen has twin bucket wheel units for the removal of clays, silts and slimes to produce 2 grades of sand. It can support maximum retention or disposal of fines. The key advantage of the machines is their ability to dewater sand, with maximum removal of water and at the same time retain maximum amount of fine saleable product.

7.12. Washing Plant

Fig-25. Washing Plant in operation (left) and Power screen (Right)

With an aim to remove clay and silt from sand and gravel, washing plants are required to be deployed at all recycling plants. Power screen T4026 helps in washing the sand and gravels to produce cleaner aggregates and has a special feature of recirculation of the water

7.13. On-Site Bucket Crushers

On site Bucket Crushers can be put on job directly at site for processing and recycling of concrete aggregates and bituminous overlays. No separate crushing and handling is required which makes it cost effective by saving the cost of transportation also and easily installable on-site.

7.14. Materials Sorting Screens & Steel Separation Magnets

Typically, mixed C&D debris is tipped at a central facility, and the materials with a high market value, such as large pieces of sawn lumber, are removed. The remaining mixed C&D materials are then processed using one of two primary methods. The mechanized size reduction method uses a crusher, a dozer, or a compactor.

The materials are then passed through a series of screens, magnets, and other separation equipment. The manual labor method relies on human sorters to pick out materials and place them in specific containers.

Fig-26. Material Sorting Screen

Screens and magnets may also be employed with the human labor method, but the materials are left in their original form rather than crushed so that they can be easily distinguished and sorted. The most common approach is a blend of the mechanized size reduction and the human sorter methods.

7.15. Concrete Recycling Plants

Specialized equipment is also available to reclaim slurry water and aggregates for reuse in concrete production these days. The demand for such eco-friendly equipment is on the rise. Slurry water is often used in concrete batching plants. With the massive infrastructure development activities going on around the country, one can see increased sightings of concrete recycling plants these days.

While concrete along with other aggregates is recycled, the same holds good for steel and other ferrous scrap that is generated from demolition projects. The salvaged material finds its way to steel mills where it is put through a series of processes in order to make them ready for reuse in construction projects.

The key to the success of recycling lies in proper planning with a comprehensive waste management plan. Developers need to formulate a plan to first of all segregate the various types of waste that is generated from demolition projects. This ensures a smooth work flow and sustainable use of demolition waste.

By building implosion or controlled demolition method, a structure can be demolished in seconds, which otherwise is cumbersome and time consuming. This method is widely used in urban areas for demolishing large structures in the developed countries. Many structures in India were also demolished using implosion techniques. Structures like chimneys can be demolished in a short span of time sometimes even less than a day. Larger structures may take up more time in preparation such as to remove columns and walls before firing the explosives.

Fig-27. Concrete Recycling Plant

The controlled demolition is done by placing a series of small explosives in strategic locations in the structure and its detonation is so timed that a structure collapses down with the gravity on itself, minimizing any damage to its surroundings. Most commonly used explosives are Nitroglycerin, dynamite to blast reinforced concrete supports in the structure. Explosives are then detonated progressively throughout the structure. This method is also used for demolition of other structures as well other than buildings.

8. C&D WASTE RECYCLING FACILITY IN NEW DELHI (IL& FS ECOSMART)

About 5000 T of C& D waste is generated in Delhi every day. Out of which 90 % is due to Re-construction activities requiring demolition of existing structures and just 10% is contributed due to new constructions taking place. Out of the total C&D waste, hardly 50 % goes to the landfills, 10 % is recycled and balance 40 % is getting illegally dumped causing all kinds of nuisance, polluting the environment, natural piece of lands and water bodies.

Fig-28. Illegal Dumping of Demolition Waste at various Location in Delhi

Types of waste received at landfills include soil/ sand, gravels, bitumen, metals, bricks, concrete wood, plastics. Most of the metals, timber, glass and plastics is almost collected separately and recycled. Out of all the constituents of total wastes, masonry (bricks as well as concrete) items and soil/sand are the main constitutes to the order of 90 %.

Fig-29. C&D Waste Management Plant setup by IL&FS at Burari, Delhi.

One pilot plant set up IL&FS Environmental Infrastructure and Facilities Ltd. for North Delhi Municipal Corporation is functioning at Burari, Delhi. The plant is built up in about 7 acres (28000 sqm) of land with a capacity to handle about 500 T of C&D waste per day.

8.1. Collection and Transportation of C&D Waste

There are designated collection points where containers and skips are placed as a first storage point of C&D waste where the waste is brought in by public and private persons. As an additional measure, sufficient vehicles re also in operation to collect the waste from various locations of the city as per the services required from pick up points. After the collection of Construction and Demolition waste, the material is routed through the Weighbridge to the processing site.

Fig-30. Skips and Containers

8.2. Processing Site

First of all silt, loose soil and muck is separated in the processing site by screening through a grizzly. This screened loose soil or muck makes more than 50% of the waste and the only option is to utilize it for landfill. In order to make an effective use of this leftover portion, pure sand is extracted by processing it wet processing system called Evowash system.

Fig-31. Evowash System

Next stage of screening is sorting of bricks and concrete manually. Before actual processing starts, the bigger sized masonry or concrete wastes are reduced to smaller size in a rock breaker. Then the leftover waste is processed in central processing unit which has mobile crushing units Rubble Master RM 60, with capacity of 60 T per hour machines for further reduction in size. This Processed C&D waste is used for sub base of roads and for making bricks, paver blocks & kerb stones. The process flow of C&D waste recycling at the plant is as under:-

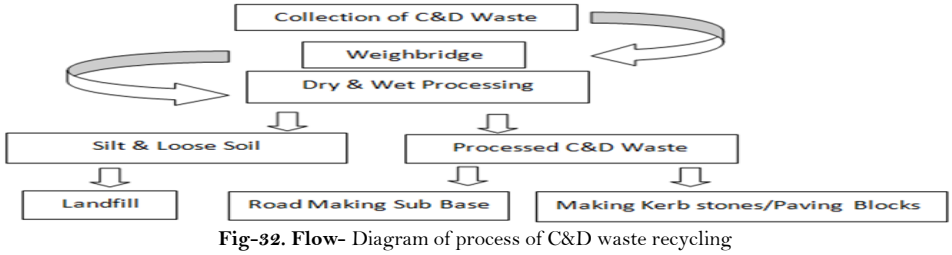

Fig-32. Flow- Diagram of process of C&D waste recycling

8.3. C&D Waste Utilization Test Road

Fig-33. Test Road with C&D Waste

8.4. Pavement Blocks and Kerb Stones

Fig-34. Pavement Blocks (Top Left), Bricks (Top Right), Tiles (Bottom Left) and Kerb Stones (Bottom Right) made from C&D waste

9. CONCLUSION

Concrete has become a high tech material and its production is used by economists as a measure of a country's economic strength. Aggregates from natural sources are not available. The situation has forced us to explore aggregate from alternate sources. It is important to minimize C&D waste generation and maximize reuse/recycling as the construction industry is consumer of tremendous amount of natural resources.

In so far as use in concrete in India is concerned, IS: 456, IS: 1343 or IRC: 112 do not permit use of aggregate other than those obtained from natural sources and conforming to IS: 383. In view of international developments and experiences, as well as shortage of aggregate from natural sources being experienced in many parts of the country, it is time that recycled aggregate are permitted for use in concrete constructions.

The Municipal bye-laws are required to be reviewed and suitably modified. Establishment of effective strategies and enactment of laws and regulations deem to be essential to achieve this. In addition, provisions of some incentives to users of the recycled products deem to be necessary to promote the use.

Research & Development is to be promoted by Government. There is lack of public awareness and it is required to spread the Information, Education and Communication in order to Garner Public Support and change the attitude of Public and Staff. Data and results should to be posted in Public Domain.

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