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Sustainable Construction – An Option for Waste Minimization in Construction

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Abstract—*The construction industry in India is booming. As against the world average of 5.5 per cent per annum; if the Indian construction industry grows at the predicated rate of 6.4% a year between 2018 and 2023; it would have a value of approximately US $ 690 billion. Almost 70 per cent of the building stock in India is yet to come up. The built-up area is expected to swell almost five times from 21 billion sqft in 2005 to approximately 104 billion sqft by 2030. Buildings are at the core of all our demands water, energy and material – but they also create huge quantum of waste. A 2012 World Bank report says that globally, cities generate about 1.3 billion tons of solid waste per year; and this figure is expected to increase to 2.2 billion tons by 2025. Building materials alone account for about half of all materials used and about half the solid waste generated worldwide.In this era of sustainable development; why not bring in the "3Rs Principle" into the construction sector and also explore the possibility of encompassing the aspects of sustainable design & construction and adopt eco-friendly methods for effective disposal of C & D waste. Through this study, an attempt is made to explore the options available for effective management of C & D waste.*

Keywords*: C & D waste, 3Rs Principle, Sustainable Design & Construction.*

1. INTRODUCTION

Infrastructure projects have been a key part of the Indian government's strategy for growth. In the year 2018 –2019 budget, the government increased its expenditure towards infrastructure development by 21% from INR 4.9 trillion (US $ 75.9 billion) to INR 6.0 trillion (US $ 89.2 billion).

The construction and demolition (C & D) waste is generated in the construction, maintenance and disposal phases of any infrastructure. It comprises of waste from construction sites, demolished structures, repair and renovation of buildings as also construction and repair of roads, flyovers, bridges, etc. In addition, huge amount of debris is generated after natural disasters viz. earthquakes, floods, volcanic eruptions etc. Building materials alone account for about half of all materials used and about half the solid waste generated worldwide.

2. QUANTUM OF C & D WASTE

According to the Technology Information, Forecasting and Assessment Council's, or TIFAC's, thumb rule [4]; the amount of C & D waste that is generated in India can be estimated as:

- For new constructions – on an average 50 kg/sq.m of floor space.
- During repair and renovation – on an average 45 kg/sq.m of floor space.
- Demolition – on an average 450 kg/sq.m of floor space.

It may not be an understatement to say that in India the amount of C & D waste that is generated per is grossly underestimated and till 2013 an authentic record of the quantum of C & D waste is also non-existent. It has been reported that India has generated C & D waste to the tune of 15 Million Tons in 2013. But, as per the estimates of Centre for Science and Environment (CSE) [1], since 2005, India has newly constructed 5.75 billion sq m of additional floor space with almost one billion sq m in 2013 itself. By assuming that that five per cent of the existing building stock gets demolished and rebuilt completely annually and one-third of the existing building stock underwent some sort of repair or renovation in 2013; the total C&D waste generated in India just by buildings in one year viz. 2013 alone amounts to a humungous530 Million Tons, 35 times higher than the official estimate.

Not surprisingly, in India, if C&D waste is quantified, it will be more than all the other types of solid waste put together. Where is all this C&D waste going? A lot of it is being used by land sharks to illegally fill up waterbodies and wetlands around urban centers for real estate development. The rest is just being dumped into rivers and open spaces.

3. WASTE MANAGEMENT REGULATION

The C&D waste can be an invaluable source of building material and there is immense scope for the C & D waste being recycled and reused. Moreover, certain materials can also be recovered from this waste; and the same can offset the use of raw materials.Till 2012, in India, the reuse and recycle route for C & D waste was just not there. The C & D waste was either being dumped astride the roads or low-lying areas on the outskirts of towns and cities or in landfills.

Ministry of Urban Development (MoUD) [2], vide its circular dated 28th June, 2012 stated all states to set up C & D waste recycling facilities in all cities with population of over one million. Unlike other rules addressing various key urban wastes such as MSW, plastic wastes, the Construction and Demolition (C & D) Waste Management Rules, 2016 are new rules that were notified on 29th March, 2016 by the Ministry of Environment, Forest and Climate Change (MoEF& CC) [3].

In adherence to the Rule 10 sub-rule 1(a) of C & D Waste Management Rules, 2016 [3], which mandates the issue of guidelines related to environmental management of construction and demolition (C & D) waste management; the Central Pollution Control Board (CPCB) has issued the guidelines to:

- Promote an integrated approach, whereby environmental management of construction and demolition waste is given due consideration throughout the duration of the project;
- Approach towards reduction of environmental impacts.

The guidelines recommend pollution mitigation measures in operation of C & D dump sites/waste processing facilities. Though guidelines focus mainly on facilities generating more than 20 tons or more in one day or 300 tons per project in a month of installed capacity (bulk generators) in cities/towns however, the mitigation measures suggested can be scaled after consultation with the concerned department in the state government.

4. COMPOSITION OF C & D WASTE

The composition of C & D waste can vary depending on age of building being demolished or renovated or the type of buildings being constructed. As mentioned earlier, C & D waste generation figures for any region vary as these depend largely on the type and nature of construction/demolition project activities which may be regional/site/project specific. Under Rule 4 sub-rule (3) the segregation by bulk C & D waste generators shall be done into four streams such as:

- Concrete
- Soil
- Steel, wood and plastics
- Bricks & mortar

In India, when old buildings are demolished the major demolition waste is soil, sand and gravel accounting for bricks (26%) & masonry (32%), Concretes (28%), metal (6%), wood (3%) others (5%). Bricks, tiles, woods and iron metal are sold for reuse/recycling. The typical composition of C & D waste in India is as tabulated in Table 1 below.

Table 1: Composition of Indian C & D Waste

Material	Composition
Soil, Sand & Gravel	36%
Brick &Masonry	31%
Concrete	23%
Metals	5%
Bitumen	2%
Wood	2%
Others	1%

(Source: TIFAC, 2001), [4].

5. THRUST AREAS FOR C & D WASTE

The National Building Code (NBC) has spelt out some key thrust areas regarding C & D waste reuse/recycling; such as:

- Establish utilization of C & D wastes in concrete and concrete based products by preparing standards.
- Quality control and certification.
- Need for popularizing products from C & D waste.
- R&D activities on continuous basis in tandem with manufacturing industry and users.
- Achieving environment protection through C & D waste utilization.
- Optimizing utilization pattern of traditional materials by interfacing the same with supplementary materials.

6. C & D WASTE MANAGEMENT INITIATIVES

Some key initiatives on C & D waste management in India are given below:

- MoUD through a circular [2] dated June 28, 2012, directed States to set-up such facilities in all cities with a population of over 10 lakhs (one million plus cities) to establish environment friendly C & D waste recycling.
- MoEF& CC [3], initiated the integrated waste management principles by stipulating that environmental considerations have to be integrated into all levels and in National Environment Policy of 2006 [5], by incorporating the concept of 3Rs. Also, the utility potential of the C & D waste has been recognized. Accordingly, the C & D Waste Management Rules, 2016 [3] were notified by MoEF& CC vide notification no. G.S.R. 317(E) dated 29th March, 2016.
- Under the Construction and Demolition (C & D) Waste Management Rules, 2016 [3], Rule (11) it has been stipulated that the Bureau of Indian Standards (BIS) [6] and Indian Roads Congress (IRC) [7] shall be responsible

for preparation of code of practices and standards for use of recycled materials and products C & D waste in respect of construction activities.

6.1 BIS 383: 2016

This standard [6], covers the requirements for aggregates, crushed or uncrushed, derived from natural sources, such as river terraces and riverbeds, glacial deposits, rocks, boulders and gravels, and manufactured aggregates produced from other than natural sources, for use in the production of concrete for normal structural purposes including mass concrete works. These manufactured aggregates are of two types namely:

- Recycled Aggregate (RA) — it is made from C & D waste which may comprise concrete, brick, tiles, stone, etc.
- Recycled Concrete Aggregate (RCA) – it is derived from concrete after requisite processing.

BIS: 383 is the principal driver, the standard for coarse and fine aggregates for use in concrete was revised in January, 2016, permitting use of recycled aggregates up to 25% in plain concrete, 20% in reinforced concrete of M-25 or lower-grade and up to 100% in lean concretes of grade less than M-15.

6.2 National Building Code, 2005

NBC, 2005 - 'Approach to Sustainability'[8] states:

- Recycled Coarse Aggregate may be used in concrete for bulk fills, bank protection, base/fill of drainage structures, pavements, sidewalks, kerbs and gutters etc.
- Up to 30 percent of natural crushed coarse aggregate can be replaced by the recycled concrete aggregate
- This percentage can be increased up to 50 percent for pavements and other areas which are under pure compression specific to the standards and practices pertaining to construction of roads.'

6.3 CPWD & NBCC

To address utilization of C & D wastes, the Central Public Works Department (CPWD) and National Building Construction Company (NBCC) have recommended use of recycled portions of C & D wastes in their construction activities or if the same is available within 100 km from construction site.

6.4 Indian Road Congress (IRC)

Under the Construction and Demolition (C & D) Waste Management Rules, 2016, Rule 11 the role of Indian Roads Congress (IRC) is cut out for preparation of code of practices/standards for use of recycled materials and products of construction and demolition waste in respect of road works.

7. SUSTAINABLE CONSTRUCTION

Sustainable construction is generally used to describe the application of sustainable development to the construction industry. The 'Construction Industry' is defined as all who produce, develop, plan, design, build, alter, or maintain the built environment, and includes building materials manufacturers and suppliers as well as clients and end use occupiers. Clients and end use occupiers also have key roles to play in delivering sustainable construction.

7.1 What is Sustainable Construction?

A sustainable approach takes account of the need for a company to prosper in business, without seeking profitability at the expense of the environment or society. It recognizes that decisions made now will have long term as well as short term impacts. Sustainability is sometimes termed the 'triple bottom line', because it involves a commitment to economic, environmental and social objectives:

- **Economic Sustainability**: increasing profitability by making more efficient use of resources including labour, materials, energy and water. It implies the construction should be 'economically feasible'.
- **Environmental Sustainability**: protecting the environment from the impact of emissions, effluent and waste and where possible, enhancing it and using natural resources, carefully; implying that the the construction should be 'environmentally sound'.
- **Social Sustainability**: recognizing the needs of everyone impacted by construction, from inception of a project to demolition - the list will include construction site workers, local communities, the supply chain and people who will use the finished product. Implies the development should be 'socially equitable'.

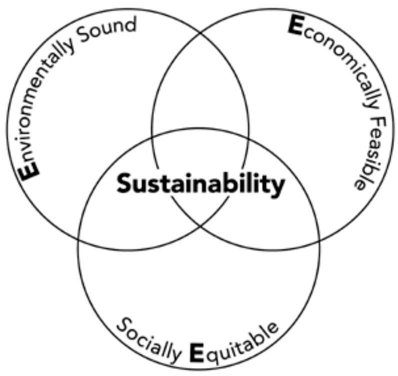

Figure 1: Sustainability

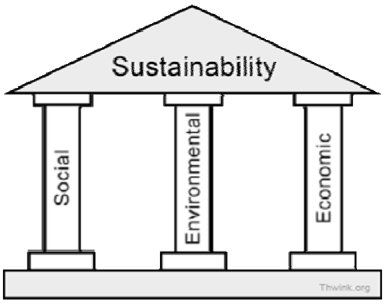

Figure 2. Three Pillars of Sustainability

7.2 Sustainable Development and Sustainable Construction

Sustainable development is modeled on the above three pillars – which depict the environmental conservation, economic growth and the social equity dimensions. These are coined to fulfill the phrase – ‘A viable – fair and liveable world’. Further it can be termed as a ‘Live & Let Live, Grow & Let Grow’ principle.Akin to these aspects the dimensions for sustainable construction can also be:

- **Social Dimension –** enhancement of people’s quality of life.
- **Economic Dimension –** employment creation, enhancement of healthy competition, skill development, lower operation & maintenance costs, conducive and safe working environment leading to greater productivity.
- **Environment Dimension –** should adopt the aspects sound design, construction, operation, maintenance &repair and deconstruction to minimize the adverse impacts on the environment.

7.3 Salient Aspects of Sustainable Construction

Any sustainable construction should adopt three criteria viz. a sustainable design and sustainable architecture along with proper building placement.

- **Sustainable Design** – building construction and operations can have extensive direct and indirect impacts on the environment, on society, and the economy, which are commonly referred to as the 3 P's ('People', 'Planet', 'Pocketbook'). The field of sustainable design seeks to balance the needs of these areas by using an integrated approach to create "win-win-win" design solutions.
- The main objectives of sustainable design are to reduce, or completely avoid, depletion of critical resources like energy, water, land, and raw materials; prevent environmental degradation caused by facilities and infrastructure throughout their life cycle; and create built environments that are livable, comfortable, safe, and productive.
- A sustainable building is designed & operated to use & reuse materials in the most productive and sustainable way across its entire life cycle, and is adaptable for reuse during its life cycle.
- The materials used in a sustainable building minimize life-cycle environmental impacts such as global warming, resource depletion, and toxicity.
- Environmentally preferable materials reduce impacts on human health & the environment, & contribute to improved worker safety and health, reduced liabilities, and reduced disposal costs.
- In addition to including sustainable design concepts in new construction, sustainable design advocates retrofitting existing buildings rather than building anew.
- Retrofitting an existing building can often be more cost-effective than building a new facility.
- Designing major renovations and retrofits for existing buildings to include sustainable design attributes reduces operation costs and environmental impacts, and can increase building resiliency.
- The "embodied energy" of the existing building (a term expressing the cost of resources in both human labor and materials consumed during the building's construction and use) is squandered when the building is allowed to decay or to be demolished.
- Building resiliency is the capacity of a building to continue to function and operate under extreme conditions, such as (but not limited to) extreme temperatures, sea level rise, natural disasters, etc.
- As the built environment faces the impending effects of global climate change, building owners, designers, and builders can design facilities to optimize building resiliency.
- Building adaptability is the capacity of a building to be used for multiple uses and in multiple ways over the life of the building.
- For example, designing a building with a modular and integrated approach to infrastructure delivery and interior systems (furniture, ceiling systems, demountable partitions and access floors) allows the building to support multiple uses and multiple futures. Additionally, using sustainable design allows for a building to adapt to different environments and conditions.
- **Sustainable Architecture** – is architecture that seeks to minimize the negative environmental impact of buildings by efficiency and moderation in the use of materials, energy, and development space and the ecosystem at large.

- Sustainable architecture uses a conscious approach to energy and ecological conservation in the design of the built environment.
- The idea of sustainability, or ecological design, is to ensure that our use of presently available resources does not end up having detrimental effects to our collective well-being or making it impossible to obtain resources for other applications in the long run.

8. THE 3 R'S OF WASTE HIERARCHY

A well-coordinated Resources & Waste Management Plan; coupled with Sustainable Design & Architecture will surely lead to optimization of resources; hence reducing the amount of raw material and ultimately resulting in minimizing the C & D Waste. The 3Rs principle is:

- Reducing –what is produced and what is consumed can reduce the amount of waste that is generated. By virtue of multi-purpose buildings, reusable building structure, prefabricated buildings a considerable reduction in the C & D Waste can be achieved.
- Reuse – items for different purposes instead of disposing them off. For example reuse door frames, pipes, windows, etc.
- Recycle – items like aggregate, steel, wood etc.

9. GO GREEN – CONCEPT

Green building or sustainable building refers to both a structure and the application of processes that are environmentally responsible and resource-efficient throughout a building's life-cycle: from planning to design, construction, operation, maintenance, renovation, and demolition. This requires close cooperation of the contractor, the architects, the engineers, and the client at all project stages. The Green Building practice expands and complements the classical building design concerns of economy, utility, durability, and comfort.

10. CONCLUSION

Sustainable construction takes account the objectives of economic, environmental and social sustainability in a balanced way at all stages of a construction project. Sustainability should be considered when first deciding whether a new building or piece of infrastructure is needed, throughout the specification and design, on the construction site, in operation (including maintenance and refurbishment), and ultimately in deconstruction or demolition.

10.1 Benefits of Sustainable Construction

According World Green Building Council (WGBC) [9], sustainable infrastructure shall accrue environmental, economic and social benefits.

- **Environmental** – Green buildings not only reduce or eliminate negative impacts on the environment, by using less water, energy or natural resources, but they also have a positive impact on the environment by generating their own energy or increasing biodiversity.
  - The building sector has the largest potential for significantly reducing greenhouse gas emissions compared to other major emitting sectors – UNEP, 2009 [10A].
  - This emissions savings potential is about 84 giga-tons of CO_2 ($GtCO_2$) by 2050, through direct measures in buildings such as energy efficiency, fuel switching and the use of renewable energy – UNEP, 2016 [10B].
- **Economic**– Green buildings offer a number of economic or financial benefits, which are relevant to a range of different people or groups of people. These include cost savings on utility bills for tenants or households (through energy and water efficiency); lower construction costs and higher property value for building developers; increased occupancy rates or operating costs for building owners; and job creation.
  - The building sector has the potential to make energy savings of 50% or more in 2050, in support of limiting global temperature rises to 2°C (above pre-industrial levels) – UNEP, 2016 [10B].
  - Green buildings achieving the Green Star certification [11A] in Australia have been shown to produce 62% fewer greenhouse gas emissions than average Australian buildings, and 51% less potable water than if they had been built to meet minimum industry requirements.
  - Green buildings certified by the Indian Green Building Council (IGBC) [11B] results in energy savings of 40 - 50% and water savings of 20 - 30% compared to conventional buildings in India.
  - Green buildings have shown to save on average between 30 - 40% energy and carbon emissions every year, and between 20 - 30% potable water every year.
  - Green buildings achieving the LEED [11C] have shown to consume 25 per cent less energy and 11 per cent less water, than non-green buildings.
- **Social** – Green building benefits go beyond economics and the environment, and have shown to bring positive social impacts too. Many of these benefits are around the health and wellbeing of people who work in green offices or live in green homes.
  - Global energy efficiency measures could save an estimated €280 to €410 billion in savings on energy spending.

- Canada's green building industry generated $23.45 billion in GDP and represented nearly 300,000 full-time jobs in 2014 – Canada Green Building Council, 2016 [11D].
- Green building is projected to account for more than 3.3 million U.S. jobs by 2018 – US Green Building Council, 2015 [11E].
- Building owners report that green buildings - whether new or renovated - command a seven per cent increase in asset value over traditional buildings – DD & A, 2016 [12].
- Workers in green, well-ventilated offices record a 101 per cent increase in cognitive scores (brain function) SUNY UMS, 2015 [13].
- Employees in offices with windows slept an average of 46 minutes more per night - AASM, 2013 [14].
- Better indoor air quality can lead to improvements in performance of up to 8 per cent [15].

Hence it can be concluded that when adopted in tandem with the 3Rs principle, sustainable construction may be technically feasible, economically viable, environmentally ethical and socially beneficial option for minimization of C & D Waste.A suggested way of C & D Waste Management is as given in the Figure 3.

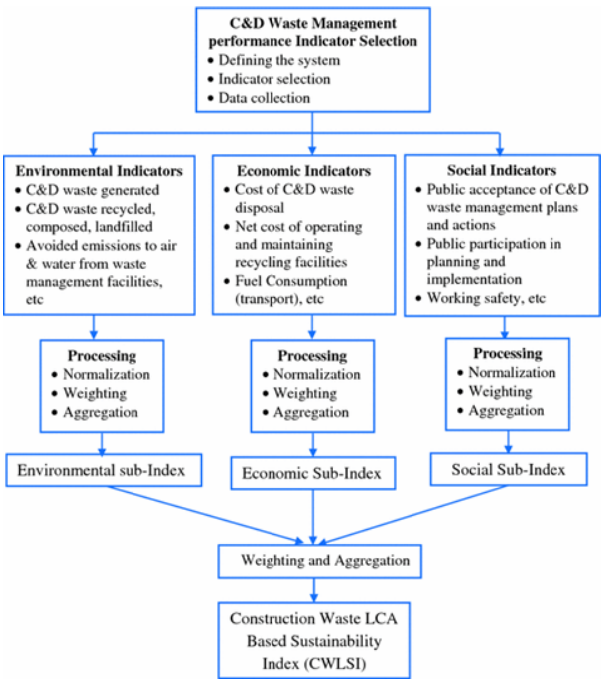

Figure 3: C & D Waste Management

(Source –Images for C & D Waste Management)

References

[1] Centre for Science and Environment (CSE) "Report on Waste", 2005.

[2] Ministry of Urban Development (MoUD), "Waste Management" circular dated 28th June, 2012.

[3] Ministry of Environment, Forest and Climate Change (MoEF& CC), the Construction and Demolition (C & D) Waste Management Rules, 2016 dated 29th March, 2016.

[4] Technology Information, Forecasting and Assessment Council's, or TIFAC's, thumb rule, 2001.

[5] National Environment Policy, 2006.

[6] Bureau of Indian Standards (BIS).

[7] Indian Roads Congress (IRC).

[8] NBC, 2005 - 'Approach to Sustainability'.

[9] World Green Building Council, 2009 Annual Report.

[10A&B] United Nations Environment Programme, 2009& 2016, UNEP 2009& 2016 Annual Reports.

[11 – A, B, C, D & E] National Green Building Certifying Agencies – [11A] – GREEN STAR, Australia, [11B] – IGBC, India, [11C] – LEED, UK, [11D] – CBC, Canada & [11E] – USGBC, USA.

[12]Dodge Data & Analytics, "World Green Building Insights, 2016".

[13] SUNY Upstate Medical School, 2015 - Upstate, Harvard, Syracuse "How better indoor environments enhance cognitive function".

[14] American Academy of Sleep Medicine, 2013.

[15] Park, J. S., & Yoon, C. H. (2011). The Effects of Outdoor Air Supply Rate on Work Performance during 8-h Work Period. Indoor Air, 21(4).