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C & D WASTE MANAGEMENT USING LIFE CYCLE ASSESSMENT TOOL - AN OVERVIEW

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Abstract: **Solid waste management is a basic and integral part of human living. All over the globe 1.3 billion tons per year municipal solid waste (MSW) is generated which is expected to increase up to 2.2 billion tons per year by 2025, against which 0.0365 billion tons per year is generated by India alone. Solid waste is managed by local bodies of countries or states involving steps of collection, processing, transportation, recycling and disposal of solid waste. However, in most of the countries, factors such as lack of infrastructure, financial support and technology which are not up to the required level leading to inefficient waste management services. Further, since construction is one of the basic need for development and GDP growth for any country, thus government policies are promoting rapid construction growth. This rapid construction growth with the lack of infrastructure for waste handling is contributing abnormally for waste generation during any construction, maintenance and demolition phases of a building. This study reviewed and applied the concept life cycle assessment (LCA) which is a parameter of green rating tool and which can be followed for a building by any government and private body. Benefits of implementing the concept life cycle assessment can then be compared with conventionally constructed buildings. The results can be used for policy decisions as well as strategic decisions on waste management systems during building planning phase only which will not only help in reducing the waste generation by reusing but also save cost and time for disposal activities. It has been observed that by simply adopting the steel material in place of concrete for building frame construction, the reduction in the overall total municipal solid waste can be made by 3.96 percent.**

Keywords – *Life cycle assessment, Construction and demolition waste, Waste management, Sustainability*.

I INTRODUCTION

Solid waste management is a mechanism of origination, storage, assortment, handling, processing and disposal of generated waste materials ensuring healthy environmental conditions. Methods of solid waste management vary from country to country whether these are developed, developing or under-developed countries. Solid waste management targets to eliminating and minimize the unfavorable effects of generated waste materials for a healthy quality of living [1].

Solid waste mainly comprises of the following [2]:

- Paper and cardboard
- Food waste
- Wood
- Textile
- Leather rubber
- Metal
- Plastics
- Glass
- Construction and demolition debris

The composition of municipal solid waste [3] is indicated in figure 1 construction and demolition debris contributes about 12% of the total solid waste for any city which is generated during construction, operation and demolition stage of any building. Although most of the construction waste products can be recycled or reused due to lack of infrastructures technology updates these generated wastes are disposed to the landfills leads to environmental concerns [4].

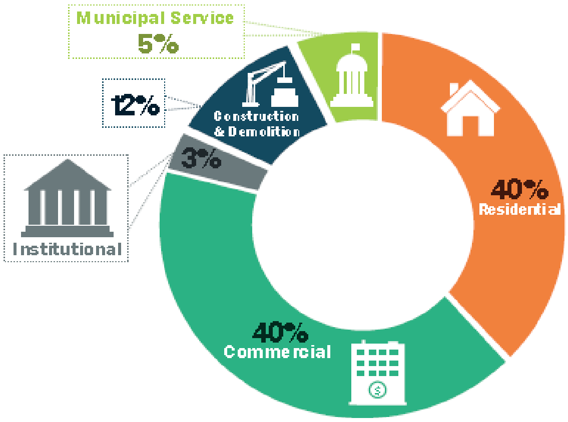

Figure 1 Composition of municipal solid waste (Source "J. R. Mihelcic and J. B. Zimmerman, "Environmental Engineering: Fundamentals", [3])

Within the European Union only, more than 450 million tonnes per year construction and demolition waste is generated. Though the construction and demolition waste are having highest recovery potential to achieve almost 80% recycling or reuse. However, on ground reality out of it 80%, a maximum 5% of waste is actually recovered and balance 75% of waste is being landfilled [5].

II SUSTAINABLE CONSTRUCTION

The concept of sustainable construction establishes a relationship between the selection of materials for construction, its utility during operation and its usage after the demolition of a building based on the principle of 3R, i.e. Reduce, Reuse and Recycle [6]. Sustainability helps in decision making at the design phase by ensuring use of eco-friendly material with high reuse and recycling rate which reduces the environmental impact due to the raw materials and in turn reduces wastage volumes. Sustainable construction evaluates all steps in building life cycle starting from raw materials production, building construction, building during operation and its end of life for demolition [7].

III LIFE CYCLE ASSESSMENT

Life cycle assessment is a method to evaluate environmental effects linked with all stages within building a life from raw material selection, it's manufacturing, construction, transportation, operation, dismantling and reuse, recycling or disposal as indicated in figure 2 [8].

Application of life cycle assessment tool for construction is a distinct area within Life cycle assessment itself due to the uniqueness of every building and of more than 50 years long lifetimes. Further, during building lifetime it undergoes many modifications in terms of its operation and function. Key factors influencing the construction material selection are:

- Cost
- Availability
- Appearance

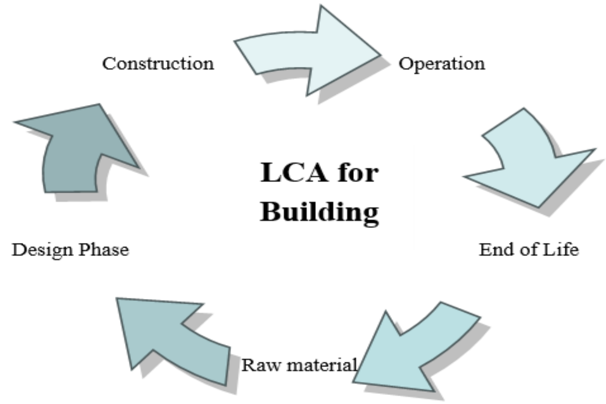

Figure 2 LCA for Building (Source "International Standard ISO 14044", [8])

However, presently in order to have an eco-friendly building environment, recycling or reuse of materials is another aspect that needs to be considered. Selection of materials during the design phase is directly related to the waste generated during the construction and demolition phases for the same building. The concept of life cycle assessment evaluates the impact of environmental conditions during complete life-cycle of the building. Life cycle assessment is done for raw material extraction, it's processing, transportation, application, use, reuse, recycling and final disposal. Thus life cycle assessment should be implemented at the design stage only so that all four aspects of cost, availability, appearance and reuse can be ensured. Life cycle assessment during design phase helps to find out better alternatives for implementation [9] [10].

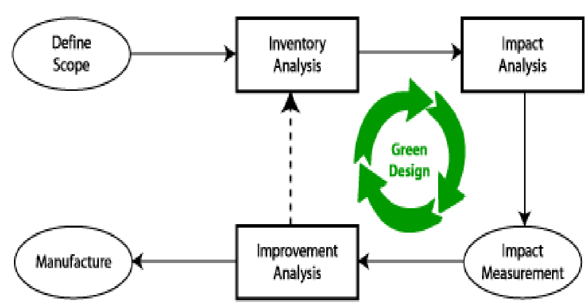

Figure 3 LCA Steps (Source "Graedel and Alleby p. 109", [12])

Inventory analysis is the first stage of a life cycle analysis wherein inputs and outputs in a raw material are examined during its life cycle. Next stage is the impact analysis, in which impact of raw material over the environment is analyzed. In next step environmental impact of raw inputs and outputs is analyzed throughout its lifecycle. Based on the above working the decision is taken for using or rejection the reviewed raw materials for the building construction [11].

IV IMPLEMENTATION OF LIFE CYCLE ASSESSMENT FOR A BUILDING FOR CONTROLLING CONSTRUCTION WASTE

Since in most of the countries handle construction and demolition is done in a very unsystematic way thus in spite of highest recovery potential to achieve almost 80% recycling, almost 75% of the waste is landfilled and illegally disposed-off. As cited by Centre for Science & Environment, in India since 2005 construction of 7.75 billion sqm new floor area took place and present yearly rate of construction is 1 billion sqm floor area. As per Technology Information, Forecasting and Assessment Council, any new building construction generates 40-60 kg of construction and demolition waste per sqm, thus solely India is generating 50 million tons construction and demolition waste per year for new building construction programs. Further demolition and modification activities generate 300-500 kg of waste per sqm which is 10 times more that any new construction activity. Above data indicate that incase if we use life cycle assessment for any building during its design phase and before construction then above waste generation not only can be minimized but can also be reused to avoid new raw material consumption [12].

As highlighted in figure 4, construction and demolition mainly comprises of 65% concrete debris, 25% bricks and tiles, 5% wood, 2% metal and balance 3% mixed plastic and rubber waste. Except 2% metal waste which is recovered and reused due to high value of resale whereas other all components are mostly dumped off in landfills [13].

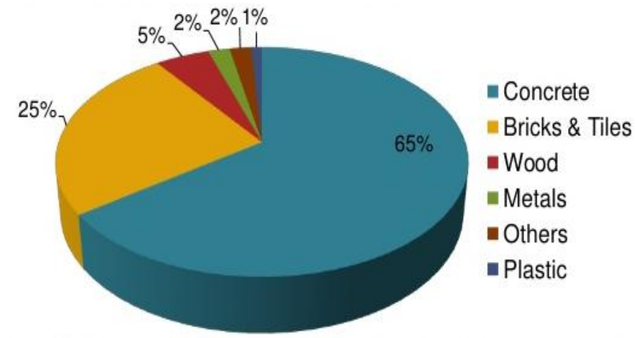

Figure 4 Composition of construction and demolition Waste (Source "Central Building Research Institute", CRIR, [14])

As per case study [14], a comparison of steel versus concrete framed building is indicated in table 1.

Table 1 Comparison of Steel versus Concrete Framed Building

Building	Building area (m^2)	Steel used (tons)	Concrete Brick (m^2)	Useful life (years)
Concrete frame	34620	400	91000	50
Steel frame	46240	2844	61000	50
Steel frame* *Same area as for concrete frame	34620	2129	45670	50

Table 2 Analysis for Potential Reduction in MSW

Building frame Type	Concrete brick (m^2)	Concrete or brick consumption (%)	Potential reduction in concrete wastage (%)	Potential reduction in C & D (%) (Concrete contributes 65% of C&D)	Potential reduction in MSW (%) (C&D contributes 12% of total MSW)
Concrete frame	91000	100	0	0	0
Steel frame	45670	50	50	33	3.96

As interpreted in table 2, based on the concept of life cycle assessment tool, if the steel-framed structure is used for building construction in place of concrete structure then the volume of concrete debris waste can be reduced by 50% which will help in reducing construction and demolition waste by 33%. Further, since the construction and demolition waste is contributing to almost 12% of total municipal solid waste, thus the step of using steel frame structure can target a reduction of almost 3.96% of total municipal solid waste.

V CONCLUSION

Life cycle assessment is one of the powerful analysis tools which evaluates the selection and consumption of material for the construction of any building during its complete life cycle and its influence on the environment. It facilitates the identification of the environmental impacts based on the raw material selection and further contribution for effective waste management. It was observed that by simply adopting steel material in place of concrete for building frame construction, reduction in the overall total municipal solid waste can be made by 3.96%.

VI RECOMMENDATION

Life cycle assessment must be followed for all the construction materials to promote the principle of 3R Reduce, Reuse and Recycle. In addition that government must introduce stringent construction code specifically to emphasize the use of the recycled materials and alternative building material must be promoted such as the use of recycled block paver and floor tiles manufactured using construction and demolition waste. Further tax policies must be formatted to promote the use of recycled waste products.

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