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Sustainable Approaches to Managing C&D Waste: A Review

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Abstract: Worldwide, rapid urbanization has resulted in extensive construction of infrastructure, focus on new building projects within cities which has contributed towards drastic surge in the generation of construction and demolition (C&D) waste. Lack of proper treatment of this waste results in adverse environmental impacts in the form of air pollution, water pollution, the lack of availability of aggregates, shortage of landfill sites etc. Therefore, there is need for effectively managing C&D waste. Rules exist for sustainably managing solid waste however, major challenge is posed by the inability to effectively plan and properly manage this system while ensuring implementation of the existing rules. This research paper presents options for managing the growing C&D wastes and also recommends mechanisms to ensure that the system is financially sustainable as well. Application of approaches such as WGR (waste generation rate), LCA (lifecycle assessment) and EPR (extended producer responsibility) is suggested.

Keywords: MSW, C&D wastes, sustainable management, LCA, WCS

1. Introduction

Currently the major issue faced by nations across the world is huge quantities of waste being generated each day. Rapid growth in population along with high rates of urbanization, higher standard of living has made managing solid waste in cities of developing countries a tough task in the absence of infrastructural services (Karak *et al*, 2012). Last few decades have seen significant growth in the rate of urbanization as per UN estimates the level of urbanization in 1950 was 30% which is projected to become 66% by the year 2050 (United Nations, 2014). Similar trend has been observed in developing countries for instance in India the population residing in cities was only 11% in 1901 it has grown significantly to almost 31% in 2011 (Datta, 2006). Concomitant with the rate of increase in urbanization is the massive quantities of solid waste which are generation each day. It is estimated that developed nations generate about 522-759 kg waste per individual per year the corresponding figure for developing nations is 110-526 kg waste per individual per year (Karak *et al*, 2012).

In India the quantity of waste has also revealed a significant jump from 64-72 MT currently to being projected 125 MT by the year 2031. Huge quantities of untreated waste (mix of biodegradable and non-biodegradable) from Indian cities lie in heaps at dumpsites in absence of effective treatment and management it results in environmental and public health issues. So, it is imperative that a focussed strategy is formulated to mitigate the solid waste management issue in the country (Ahluwalia and Patel, 2018).

Urbanization has also resulted in extensive construction of infrastructure focus on new building projects in cities has contributed towards massive increment in the C&D waste generation over the past few years (Jain, 2021). Further if this category of waste is left untreated it will cause unfavorable environmental impacts such as severe air pollution, water pollution, the lack of availability of aggregates, shortage of landfill sites etc. Therefore, there is an urgent need for proper management of C&D waste (Kolaventi *et al*., 2017). An important component of the MSW is C&D i.e. Construction and

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Demolition waste, as per estimates in India each year almost 150 MT of C&D waste is generated however, only about one per cent is recycled (CSE, 2020). Hence, there is need to focus on sustainable strategies for managing this waste.

1.1 Municipal Solid Waste (MSW)

For effective management of solid waste, it is important to first discuss about MSW generation in the country, its composition and the issues in its handling as well as disposal. Municipal Solid Waste (MSW) refers to the solid waste that is generated from urban areas which mainly includes waste collected from households sometimes even commercial waste collected from markets, C&D debris, sanitation residue from cleaning of street nallahs and the soil/dust waste collected from the streets by sweepers from an urban local body present within a particular area. Generally, such wastes are present either in solid or semi-solid state and do not comprise of hazardous wastes derived from the industries. The five main categories of MSW are:

- Biodegradable waste: includes food waste and leaf litter derived mainly from kitchen and garden
- Recyclable material: it includes paper, bottles of glass, metals cans, specific plastics etc.
- Inert waste: comprises of debris from C&D, rocks, etc
- Composite wastes: generally, consist of old and discarded clothes, tetra packs from milk, oil, juices and old as well as broken plastic toys.
- Domestic hazardous waste: used sanitary pads, left over or expired medicines, e-waste items, chemicals from pesticides and sprays, light bulbs and tubes etc (Zhou *et al*, 2014).

1.2 Adverse Impacts of MSW on Environment and Health

Direct burning of waste and its decay in open spaces results in emissions of hazardous gases, intermixing of particulates and release of volatile substances in the air. On account of rainfall there is mixing of chemicals and biological components that are present in MSW which results in widespread contamination of soil, surface water bodies and the groundwater due to percolation (Fig. 1). Organic waste decomposition leads to generation of Methane which is GHG and contributes to climate change. Further, the higher organic content of MSW enhances microbial growth, causing infectious diseases in rag pickers, waste handlers and residents in the vicinity. Several types of health issues such as diseases of the respiratory system, irritation in skin, eyes as well as nose, problems in the gastrointestinal tract, various allergies and even psychological disorders have been observed on account of MSW burning (Salemdeeb *et al*., 2017; Kandasamy *et al*., 2013). It is also reported that the inter-mixing of domestic biomedical waste and health care products increases the risk of contamination and may lead to heightened risks for HIV and Hepatitis B (CPCB, 2016).

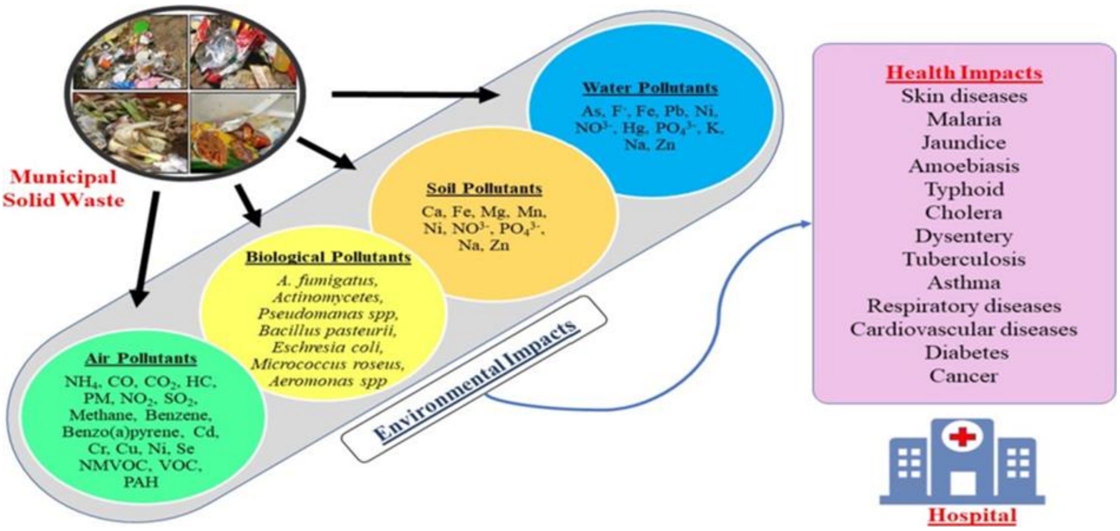

Fig. 1 - Associated environmental and health effects from improper management of MSW (Ramachandra *et al*, 2014)

1.3 Status of MSW Generation in India

As per data from the Central Pollution Control Board (CPCB 2016), in 2015 urban India generated 62 MT of MSW which came almost 169,864 T waste generation on a daily basis. The per capita waste generation each day was about 450 g. Waste collection efficiency was 82% (50 MT of total MSW) was collected and only 28% (14 MT) of the total waste collected was treated while the rest of the waste about 36 MT was dumped (CPCB 2016). CPCB report pointed out waste production rate is low, ranging between 200 and 300 g per person per day for smaller towns or cities (population below 0.2 million) with increase in population of cities there has been a corresponding rise in per capita waste generation. MSW production rate varied from 300–350 g per person per day for cities with populations ranging between 0.2-0.5 million which further increased to 400–600 g per person per day in cities with population reaching about 1 million (CPCB, 2015; CPHEEO, 2016).

From Fig. 2 it is clear that about 20% of MSW is inert silt and C&D waste. Even if this component of MSW is reduced, reused or recycled effectively it could increase waste treatment efficiency and also mitigate air, water and soil pollution as well as associated health impacts on the population.

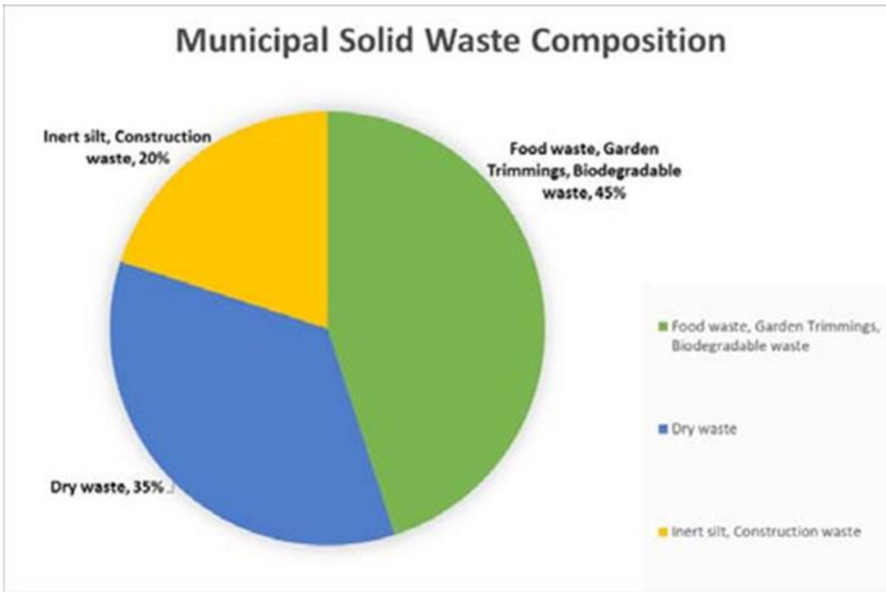

Fig. 2 - MSW composition in India (CPCB, 2015)

2. Construction and Demolition Waste

2.1 C&D Waste Generation

Each year India generates almost 150 MT of C&D waste. The major activities generating C&D waste are construction of roads, bridges, flyovers, housing complexes (Fig. 3). Small quantities of this category of waste are generated by households.

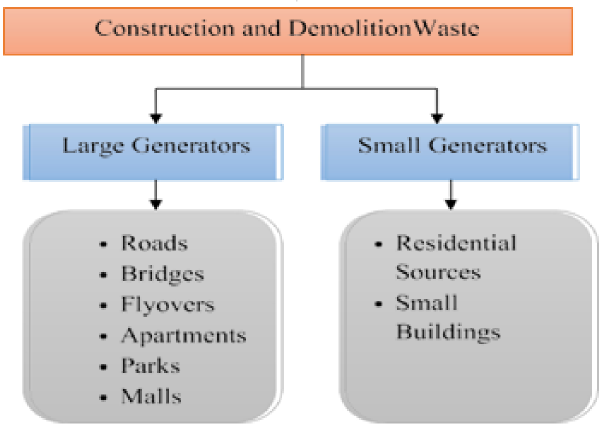

Fig. 3 - C&D waste generators (Rani and Gupta, 2016)

Table 1 presents the waste generated by Indian mega cities. It is evident that huge quantities of C&D waste are generated in Chennai, Mumbai, Kolkata and Bengaluru. In India the major components of C&D waste are sand, gravel, bricks and concrete as tabulated in Table 2. Together these comprise of almost 60% of total C&D waste generated in the country.

Table 1 - C&D waste generation in Indian cities (CPCB, 2017)

City	Population	C&D waste generation per day (Tonnes per day)
Ahmedabad	6063047	700
Bengaluru	8443675	875
Bhopal	1917051	50
Chennai	6500000	2500
Jaipur	3471847	200
Patna	2514590	250
Mumbai	12442373	2500
Kolkata	4496694	1600

Table 2 - Profile of Indian C&D waste (CPCB, 2017)

No.	Material	Composition (%)
1.	Sand and Gravel	36
2.	Brick and Masonary	31
3.	Concrete	23
4.	Metals	5
5.	Wood	2
6.	Bitumen	2
7.	Others	1

2.2 C&D Waste Definition

'C&D waste' this term is usually applied for referring to the solid waste which gets generated within the construction sector. This term is used for the waste that originates from activities which involve either construction or renovation of existing structures or the demolition of a site or structure. Such activities include excavation of land, construction of civil structure and building, clearance of existing site, roadwork, demolition activities and the renovation of existing buildings (Shen *et al*., 2004). Construction, demolition and renovation altogether result in generation of considerable quantities of C&D waste across the globe on an annual basis (Fig. 3). In USA about 136 MT of C&D waste is generated annually, however just 20–30% gets recycled (Sandler and Swingle, 2006). Similarly, in the UK, it has been reported that almost 70 MT of C&D materials are produced on an annual basis (DETR, 2000). Further it was highlighted that the wastage rate within the country's construction industry was quite high at about 10– 15% (McGrath and Anderson, 2000). According to estimates, C&D waste in Australia accounted for about 16–40% of the total MSW (Bell, 1998). In 2007, Hong Kong generated as much as 2900 tons of C&D waste on a daily basis which was transported to landfills as reported by its Environment Protection Department (EPD), (Hong Kong EPD, 2007). China generated almost 29% of the global MSW on an annual basis, the construction activities contributed for about 40% of the total MSW that was generated in the country (Dong *et al*., 2001; Wang *et al*., 2010). The basic principle of sustainable C&D waste management includes the 3Rs implying the top priority to reduce waste generation, secondly to reuse the generated waste as far as possible, and finally recycling waste when reducing and reusing are not possible (Peng *et al.*, 1997).

2.3 Adverse Impacts of C&D Waste

C&D waste generation is associated with numerous adverse impacts such as requirement of large spaces for landfilling while land resources are scarce in urban areas particularly in the developing countries (Poon *et al*., 2003), causing air and water pollution in the surroundings (Esin and Cosgun, 2007). While it is known that the generation of C&D waste is inevitable and the approach of 'zero waste' is not pragmatic, in the past few decades there has been emphasis on research and development (R&D) that pursues solutions for minimizing the C&D waste generation. In accordance with these advances in R&D, a waste management order has been well known and it comprises of four levels (Fig. 4), firstly reduction of waste, waste reuse followed by waste recycling and finally disposal of waste (Peng *et al*., 1997;). The focus is on curtailing the consumption of resource and also averting environmental pollution (Peng *et al*.,1997).

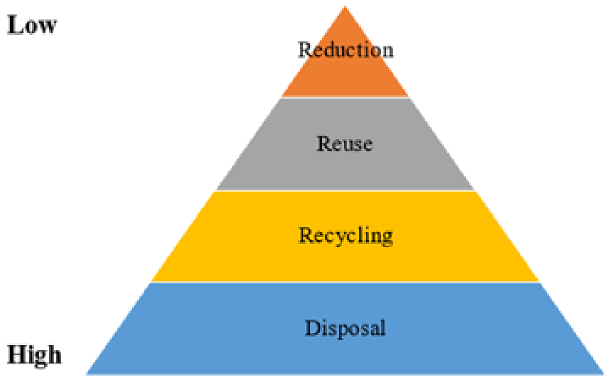

Fig. 4 - C&D waste management hierarchy

2.4 Benefit of Waste Reduction

Three ''Rs''- C&D waste management in research as well as practice is based on the ''3Rs'' principle, popularly this is also referred to as the pyramid or hierarchy of C&D WM. 3Rs which include reduce, reuse and recycle are used for classifying the strategy as per its desirability (Peng *et al*., 1997; Troschinetz and Mihelcic, 2009). 3Rs are organized in an ascending order based on their harmful environmental impacts from lower to higher. However, it is necessary to highlight that 'Reduction' is found to be the most effective methodology for managing C&D waste and it mitigates several problems associated with waste disposal as well as the related environmental issues (Esin and Cosgun, 2007). Since reduction is accorded the topmost priority for C&D waste management, this strategy has been extensively studied by various researchers. Such investigations have provided different solutions for reducing waste, that may be summed up into five categories (Begum *et al*., 2007), involving: (i) waste reduction through governmental legislations; (ii) waste reduction by design; (iii) formulating an efficient system for managing the waste; (iv) application of low waste generating technologies; and (v) guiding practitioners through behavioural change for reducing waste.

Reduction of waste provides two key benefits which are firstly reducing C&D waste generation and cutting on the cost incurred in transportation, disposal and the recycle of waste (Poon, 2007; Esin and Cosgun, 2007).

However, C&D waste is inevitable, so when it gets generated the approaches of reuse and recycle (Fig. 5) are applied for reducing the quantity of C&D waste that reaches the landfills. Reuse generally implies utilizing the same substance for similar function at least more than one time within construction (for e.g., timber formwork is made use again in construction) (Ling and Leo, 2000). A different type of reuse format is for new-life wherein the substance is utilized as raw-material for an entirely new purpose (for e.g., use of the cut-corner steel bar for constructing shelves and utilizing a fraction of concrete and bricks for road base material) (Duran *et al*., 2006). Waste materials which are unable to be reused would either get recycled for preparing newer materials for construction or are finally disposed at landfills. Reuse remains the best alternative after reduction since it needs least processing as well as low energy usage (Peng *et al*., 1997). In case the waste which is produced is unable to be reused, it is important to consider recycling. With the use of recycling, C&D waste may be transformed into entirely different materials. Authors (Kartam *et al*, 2004; Tam, 2008) have highlighted the key benefits derived from recycling of waste that include: (i) reducing the need for additional resources;(ii) reducing the costs associated with transportation and production energy; (iii) utilization of waste which otherwise would have made way to landfills (iv) conserving land for future urban development and (v) enhancing the overall state of the local environment. In those cases, where C&D waste is unable to be reused or recycled, it has to be properly disposed of at landfills for preventing pollution to the immediate surroundings.

From the above discussion it is clear that as compared to the strategies of reduce and recycle few investigations have been undertaken on reuse. Further, with regard to recycling two main issues of concern are the cost of the recycled material as well as its wide acceptability.

It is important to note that economically, materials that are recycled are desirable only when these are able to compete with the newer products with regard to quality as well as the cost. It is to be noted that usually the cost of a virgin material comes out to be lower as compared to the recycled material (Tam and Tam, 2006). Dakvale and Ralegaonker (2014) concluded that masonary and concrete can be used for producing bricks, that are at par with traditional bricks utilized in buildings. Hence, such sustainable products can meet demand for building material in future. Arora (2015) proposed that as natural resources are limited their wastage should be regulated. Execution of waste management at each step during construction would reduce the generation of C&D waste. Successful reuse and recycling of C&D waste is possible by promotion through education as well as information. Ganiron Jr (2015) opined that concrete does not face significant competition from other materials which are recycled. Gayakwad and Sasane (2015) highlighted that as C&D waste quantities increase in the future, it would be tough to manage this type of waste therefore, segregation of C&D waste must be encouraged at the source. The reuse and recycling of waste such as manufacture of tiles from construction debris should be promoted.

Fig. 5 - Various constituents of C&D waste

3. Construction Sector Waste Management – Framework

C&D waste management is research focus (Fig. 6), it is indicated by diamond. Strategies for managing C&D waste being denoted by a hexagon include waste reduction, reusing, recycling and disposal. Ellipses represent the nodes in the framework. Lines and arrows denote association or relationship between the two items.

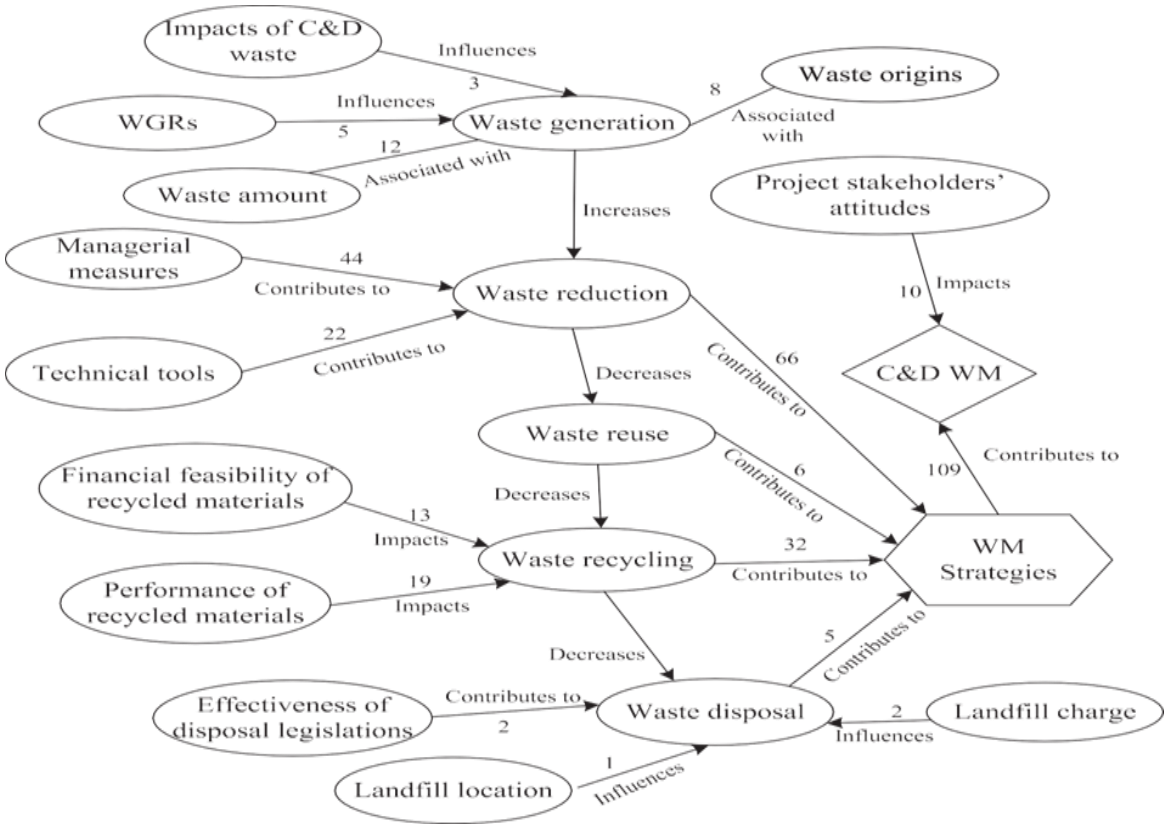

Fig. 6 - Proposed framework for C&D waste management

3.1 C&D Waste Management Strategies

(a) Waste Generation Rate (WGR)

WGR helps in understanding the management of waste within the construction sector. It involves data collection through observing contractor's records, consultation through construction firm staff members, truck load records, measurements, telephonic surveys, onsite sorting as well as weighing of the waste materials. WGR can quantitatively present useful information for comparing various practices for managing construction waste. It helps in raising public awareness regarding waste management in construction sector and also motivates the contractors in formulating efficient practices for managing waste. The significance of WGR lies in the fact that it highlights potential issues and also presents major reasons for inefficiency (Formoso *et al*, 2002). Therefore, by estimating C&D WM performance on the basis of WGR, various practices for waste management may be standardized so that efficient strategies for WM can be formulated.

(b) Life Cycle Approach

C&D waste management must be applied to the complete life cycle since every stage during a project's life cycle i.e. right from its initiation, designing, construction and operation, repair and restoration, and even demolition, significantly contributes either directly or indirectly towards the efficiency of C&DWM (Osmani *et al*., 2008; Esin and Cosgun, 2007). Researchers of C&D reveal that often the recycled materials have to compete with the virgin materials with regard to their quality and the cost. Further the practitioners are aware that the actual cost of virgin materials is actually lesser than that of the materials which are recycled (Tam and Tam, 2006) so they have lesser incentive to use recycled materials in the construction. Also, the public perception is against the recycled or reused materials often due to quality concerns. Several studies have laid emphasis on the applicability as well as attributes of the recycled materials (Al-Salem and Lettieri, 2009). LCA has found high acceptance within the industry as it provides solution to many issues which plague the businesses such as the low trust levels, addresses risks, discontinuity in production, absence of sustainability etc. Following a long period of adoption of this concept, LCA has been welcomed by the industry and academia alike as evidenced by the several Life Cycle Assessment (LCA) or the Life Cycle Cost (LCC) methodologies (Chaya & Gheewala, 2007; Zhao *et al*, 2009).

(c) Polluter Pays Principle

On the basis of the 'polluter pays principle' (PPP), certain economies have brought out the waste charging schemes (WCS) which are considered effective for managing C&D waste. WCS is a strategy which is formulated to levy a charge on persons or firms disposing off their C&D trash into the public landfill sites. Hence, it is also referred to as the landfill charging scheme or the waste disposal charging scheme. This charging scheme is proposed for providing an economic benefit for the stakeholders in order to encourage them to reduce the waste and also to promote the recycling as well as the reuse of waste material which also slows down the pressure on capacities of existing landfills (Hao *et al*., 2008). The theoretical explanation provided by economists is that the lower cost associated with the dumping of the C&D waste results in polluters i.e. the C&D waste generators disposing off their maximum waste in landfills, while it is the society which bears the environmental cost which results from the disposal of waste. Hence, the policy maker must safeguard that the society is not made to suffer external cost through approaches such as the WCS (Duran *et al*., 2006; Craighill and Powell, 1999).

(d) Waste Charging Schemes (WCS) / Extended Producer Responsibility (EPR)

Waste is treated as a penalty by few researchers (Tam, 2008) whereas others consider it as an inducement (Hao *et al*., 2008). The perspective of shifting from considering waste as a penalty towards viewing it as an incentive is not mere wording it differently but the C&D waste generators need to be educated on the aspect that paying a charge for pollution is actually an obligation while saving through managing this waste would be indeed an incentive. Another argument concerning this issue is regarding the fact that it is not just the contractors who are the sole polluter in the construction sector hence, the current practice of charging only the contractors is neither reasonable nor efficient. Recently there is focus on Extended Producer Responsibility (EPR) i.e. to charge the vendors of material for the waste which is generated by them. It is also being explored theoretically whether it will be useful for a WCS to charge all concerned stakeholders involved within a construction project who contribute towards C&D waste generation whether involved directly or when they are associated indirectly (Sauer *et al*, 2008).

(e) Gree Public Procurement (GPP)

A very useful opportunity for the construction sector's development is the application of the guidelines on the GPP in 2015 for the utilization of recycled aggregates. Among EU countries Italy has been the 1st nation which has applied the CAM that is the minimum criteria within the environmental sector. It emphasizes the significance of green procurements as a strategic means. This law includes program agreement as well as various incentives which are targeted towards supporting the reuse and recycling sector. Presently the tools and techniques which are necessary for the effective implementation of GPP within the construction sector have been formulated. Despite this development recycled aggregates do not find much application in the construction sector. There is need to organize current waste disposal in phases so that there is effective re-use of the waste or recycled material. During the process of demolition, waste needs to be separated into hazardous as well as non-hazardous waste. Further differentiation of the waste is necessary so that the waste stream that can be recycled is used again while the material which cannot be reused again would be termed as non-recoverable.

(f) Initiatives for the Promotion of C&D Waste Recycling in India

C&D waste reuse and recycling remains low in India therefore several initiatives have been taken up at the national and state level for C&D waste management. Ministry of Urban Development (MoUD) through a circular in 2012, gave directions to the States for setting up C & D waste recycling facilities in all million plus population cities. The Ministry of Environment, Forests and Climate Change (MoEF & CC) in 2016 notified the C&D Waste Management Rules, 2016. Bureau of Indian Standards (BIS) and Indian Roads Congress (IRC) were allotted the responsibility for the preparation of Guidelines for the use of recycled materials as well as products from C&D Wastes (CPCB, 2017). MoEFCC along with the states was assigned the responsibility for preparing action plan for reduce, reuse as well as recycling of C&D waste with clear cut targets and timelines for achieving those targets.

3.2 Factors Affecting Generation of C&D Waste

(a) Changes in Design

In case the materials for construction are purchased in accordance with the design which has been finalized, the materials which are unable to be reused or resold to the contractor, those items have to be dumped. Once a structure has been constructed, any modification in the design would cause generation of waste. Hence, waste generation during project design is a complicated process on account of wide range of materials being used as well as the involvement of diverse stakeholders other than the designers. Owing to such a complex situation there is low possibility of efforts being made for minimizing the waste. Studies have found that proper design consideration can play a significant role in reducing the generation of C&D waste. Research by Osmani *et al* (2008) revealed that almost 33% of waste that is generated on-site is associated either directly or indirectly with the design of project. It has been concluded that generation of C&D waste would be minimal in case proper strategies and practices for managing waste are considered right in the design stage through the use of standard sized supplies for building (masonry blocks, windows, dimension length lumber etc.), and the adoption of pre-fabricated or modular materials (Jaillon *et al*., 2009; Innes, 2004). However, in real scenario the management of C&D waste is not accorded high priority in the project design stage (Osmani *et al*., 2006).

(b) Investment in C&D Waste Management

Investing in management C&D waste would assist in encouraging the C&D waste management practices in different ways. Such practices would generally involve workers (Fig. 7) accountable for waste collection on-site, categorization and handling, purchase of equipment and the machines for managing the waste, development as well as execution of plans for waste management, encouraging the practitioners for minimizing the C&D waste and improving the skills of operators for handling waste by means of suitable vocational training.

(c) Regulatory Framework for C&D Waste Management

The significance of extensive governmental regulations for support in managing C&D waste has been well researched. Studies have established that by enforcing stringent regulations for the C&D sector, government plays an important role (Karavezyris, 2007). Governmental support through regulation was identified as a crucial factor in effective C&D waste management in Chinese city of Shenzhen (Lu and Yuan, 2011). However, few studies published previously suggest that the role of governmental regulations with regard to managing the C&D waste within certain economies was limiting. For example, while the Government of Hong Kong in 2008 implemented several regulations for minimizing the C&D waste, it was concluded that the obligatory system for executing the waste management plan within the construction projects significantly reduced the firm productivity (Tam, 2008). This has also been reiterated by findings from other authors (Shen and Tam, 2002), who have argued that the legal measures have not been very effective in executing environmental management within Hong Kong's construction industry. In Bulgaria, C&D waste is jointly managed along with the municipal solid waste therefore, the regulations are directed towards minimizing municipal waste management (Zaharieva *et al*., 2003).

(d) Site Space for Performing Waste Management

Site space is the space that is used for collection, segregating and handling of the C&D waste on-site. As the C&D waste is usually a mix of inert, organic materials, this mixed as well as contaminated waste is unsuitable for purposes of either reuse or recycling it is therefore, disposed of directly at landfill sites (Shen *et al*., 2004). It is extensively perceived that the sorting of waste on-site is effective in accomplishing a better rate of waste reuse as well as recycling. Site space was concluded to be the most significant factor during the selection of on-site segregation schemes in Hong Kong (Poon *et al*, 2001). In the absence of a pre-planned space for the collection and segregation of C&D waste, there may be chaos at the construction sites (Wang *et al*., 2010). Evidence has shown that effective waste segregation would prolong the lifespan of landfills for gathering the non-inert C&D waste (Hao *et al*., 2008). Also, effectively achieving waste segregation at on-site would significantly reduce the pollution to the surroundings (Shen *et al*., 2004). Hence, sufficient space for allowing on-site waste segregation is crucial for maximizing the reuse and recycling of C&D waste.

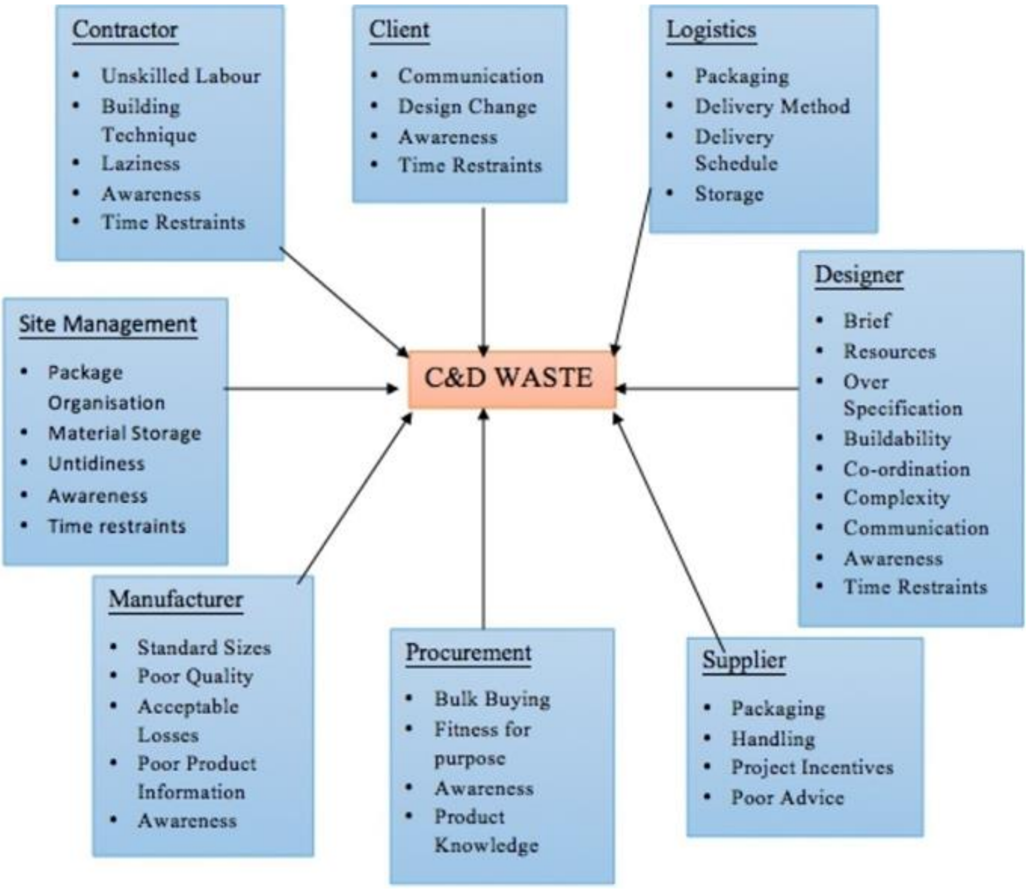

Fig. 7 - C&D waste stakeholders

(e) Adoption of Low-waste Construction Technologies

Low construction waste technologies would help in reducing, reuse and recycling of C&D waste. These technologies comprise of pre-fabrication, falsework, novel form work and low waste structures etc. Earlier studies have examined the potential of lower waste construction technologies, like pre-fabrication and use of modular structure for reducing the C&D waste generation within buildings. Reduction in waste has been significant when pre-fabrication is done as compared with traditional construction (Jaillon *et al*., 2009). The reduction in waste is almost 52%. Tam and Tam (2007) study concluded that with the use of pre-fabrication within concreting a 90% reduction in waste was possible as compared to cast in situ. These facts clearly suggest that the greater use of low-waste technologies within construction would significantly reduce the generation of C&D waste.

4. Discussion

Rapid urbanization world over has resulted in extensive focus on construction of infrastructure particularly in the cities, leading towards massive increment in the C&D waste generation. Untreated C&D waste it will cause unfavourable environmental impacts. Therefore, there is an urgent need for focus on sustainable strategies for managing this waste.

Estimates from India reveal that 20% of MSW is inert silt and C&D waste. Even if this component of MSW is reduced, reused or recycled effectively it could increase waste treatment efficiency and also mitigate air, water and soil pollution as well as associated health impacts on the population. Each year India generates almost 150 MT of C&D waste. The major activities generating C&D waste are construction of roads, bridges, flyovers, housing complexes. Huge quantities of C&D waste are generated in Indian mega cities Chennai, Mumbai, Kolkata and Bengaluru. Major components of C&D waste are sand, gravel, bricks and concrete. Together these comprise of almost 60% of total C&D

waste generated in the country. Estimates from developed countries indicates that in USA about 136 MT of C&D waste is generated annually, while only 20–30% gets recycled. Similarly, in the UK, almost 70 MT of C&D materials are produced on an annual basis. C&D waste in Australia accounted for about 16–40% of the total MSW. Even in China C&D waste comprised about 40% of the total MSW.

The generation of C&D waste is inevitable and the approach of 'zero waste' is not pragmatic, in the past few decades there has been emphasis on 3Rs approach - reduction of waste, waste reuse followed by waste recycling and finally disposal of waste. Reduction is accorded the topmost priority for C&D waste management; this strategy has been extensively studied by various researchers and may be summed up into five categories (i) waste reduction through governmental legislations; (ii) waste reduction by design; (iii) formulating an efficient system for managing the waste; (iv) application of low waste generating technologies; and (v)guiding practitioners through behavioural change for reducing waste. Several strategies for managing C&D waste include -waste generation rate (WGR), Lifecycle approach (LCA), Waste charging scheme (WCS)**,** Extended Producer Responsibility (EPR). Green public procurement (GPR).

WGR highlights potential issues and also presents major reasons for inefficiency so, by estimating C&D WM performance on the basis of WGR, efficient strategies for WM can be formulated. Application of LCA significantly contributes either directly or indirectly towards the efficiency of C&DWM. WCS is a strategy which is formulated to levy a charge on persons or firms disposing off their C&D trash into the public landfill sites. Extended Producer Responsibility (EPR) i.e. to charge the vendors of material for the waste which is generated by them. A very useful opportunity for the construction sector's development is the application of the guidelines on the GPP for the utilization of recycled aggregates. Legal measures have not been very effective in executing environmental management within Hong Kong's construction industry. In Bulgaria, C&D waste is jointly managed along with the municipal solid waste therefore, the regulations are directed towards minimizing municipal waste management. sufficient space for allowing on-site waste segregation is crucial for maximizing the reuse and recycling of C&D waste. Low construction waste technologies would help in reducing, reuse and recycling of C&D waste. These technologies comprise of pre-fabrication, falsework, novel form work and low waste structures.

5. Conclusion

C&D waste is being generated at rapid pace, it comprises of 20-40% of MSW and about 60% of C&D waste can be reused and recycled. Application of approaches such as WGR, LCA and EPR would be useful in managing C&D waste. In addition, strong implementation of legislations to curb C&D waste generation and its management, application of proper design aspect right from start of construction, sufficient space onsite for waste segregation and the adoption of low construction waste technologies can play a role in reducing C&D waste generation.

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