BUILDING DEMOLITION WASTE MANAGEMENT PRACTICES – AN INDIAN CASE STUDY

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ABSTRACT

Sustainable development has become an increasing concern throughout the world in the last two decades. Construction industry generates a huge quantity of waste, which is termed as construction and demolition (C&D) waste. C&D waste constitutes a major portion of the total solid waste generated in a society. Therefore, adoption of sustainable practices in C&D activities is vital for a society to move towards sustainable development. Moreover, demolition is a phase of construction that produces a large quantity of waste and hence requires explicit attention. During the past few decades, considerable amount of C&D waste is recycled in the developed countries. However, there are very few actively functioning C&D waste recycling facilities available in India. This signals the magnitude of the problem that needs to be addressed with respect to C&D waste management in India. In this paper, a case study research methodology is adopted to study the demolition waste management practices being adopted in Chennai city and the barriers that prevent the recycling of C&D debris have been discussed. The practices were found to be driven purely by economic incentives and unauthorized disposal of C&D waste is prevalent. There is a lack of awareness regarding the recycling possibilities among the stakeholders. Moreover, there are no records containing details on the quantity of C&D waste getting generated. Lack of appropriate policies, rules and strategies to address the C&D waste management have also been found to be some of the major barriers for the lack of C&D waste recycling initiatives in India.

Keywords: *Barriers; C&D Waste; Demolition; Recycling; Waste Management Practices.*

1. INTRODUCTION

Infrastructure is considered to be one of the important drivers of the economic growth of a country. As per the Twelfth Five Year Plan (2012-2017), India’s Planning Commission has projected an investment of around 1 trillion US dollars for the infrastructure sector. It is believed that 45 percent of that investment is towards construction (Deloitte, 2014). Construction activities contribute around 8% to India’s GDP. Moreover, the number of demolition activities is steadily increasing in the urban areas in order to make way for development. The main reasons for demolition includes obsolescence of the built facilities, change in expected requirements from the facilities, expansion due to economic growth etc. While the construction industry significantly contributes towards the development of a society, it is also seen as a major contributor to environmental degradation (Poon *et al.*, 2007). Some of its negative impacts on the society are land depletion, energy consumption, solid waste generation, dust and gas emission, noise pollution, and consumption of natural resources including non-renewable resources (Lu and Yuan, 2010). The waste that is generated during construction and demolition activities is generally termed as Construction and Demolition (C&D) waste. C&D waste also include those wastes that arise due to activities such as renovation, site clearance and land excavation.

Researchers around the world have reported that C&D waste constitutes around 30% to 35% of the total solid waste generated in a society. The US generated around 128 million metric tons of building related C&D debris in the year 1996 (Franklin Associates, 1998). The European Union as a whole (EU-15 countries) reported around 180 million metric tons of core C&D waste generation in the year 1999 which excludes excavated soil and other such kinds of waste (Symonds, 1999). The annual generation of C&D

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waste in Hong Kong was around 20 million tons in 2004 (Poon, 2007). The absolute quantity of the C&D waste getting generated signals the need for explicit attention and management in order to move towards a sustainable society.

C&D waste includes concrete debris, brick masonry debris, reinforcement steel, broken tiles, wood, paper, plastics, electrical wires, sanitary fittings etc. Most of this waste is inert in nature. It is reported that over 50 % of C&D waste is mainly confined to concrete and masonry debris (Cochran *et al.*, 2007). This debris can be crushed and processed to produce recycled aggregates that can be substituted for natural aggregates in the production of concrete and other construction materials. However, they end up getting dumped in landfills or unauthorized places.

On the other hand, the need for aggregates in the construction industry is increasing. However, the supply is getting restricted due to the ban imposed on quarrying of aggregates in many states in India. On account of such a ban, many construction projects face shortage of aggregates and are forced to look for alternative resources. The use of materials recycled from C&D waste can address this issue to some extent. However, the quantity of C&D waste recycled in India is negligible.

In India, there are very few C&D waste recycling facilities available to process the C&D waste generated. The lone facility operating in the National Capital Region (NCR) of India has a capacity to process about 500 tons of C&D waste per day. On the other hand, Netherlands has around 120 C&D waste recycling facilities with an average capacity of 400 tons per day (Symonds, 1999). The population of Netherlands is about 16.9 million (2015 estimate) whereas the population of NCR is about 54million (2011 estimate). This statistic illustrates the magnitude of the problem to be addressed with respect to handling of C&D waste in India. Therefore, there is a need to investigate the reasons for such a low recycling activity in India. The waste management practices of the industry need to be studied in order to evaluate various policies and strategies that can induce sustainable practices in the industry.

A study was undertaken to investigate the demolition waste management practices being adopted in Chennai city by conducting case studies on demolition projects. The barriers being faced in setting up recycling facilities have also been discussed. The practices adopted in demolition projects were only studied and the study of construction waste management practices is beyond the scope of this study. The rationale for choosing to study only the demolition projects is that the quantity of waste generated during demolition is almost ten times of that generated during a construction project (Duan *et al.*, 2015). The study was conducted in Chennai city, the fourth largest metropolitan city of the country. Chennai city is the capital of the state of Tamil Nadu and is spread over an area of about 426 km^2 with an estimated population of about 8.7 Million.

The paper is organized as follows. In the next section, the best practices, strategies and policies of some countries that have successfully implemented C&D waste recycling initiatives have been reviewed. In the third section, the findings of the case studies conducted on demolition projects in Chennai city have been discussed. The waste management practices being adopted in Chennai city have been compared with international best practices. The barriers posed because of unsustainable practices have also been discussed in the next section. Finally, the paper closes with the concluding remarks and the future work that has been planned.

2. REVIEW OF WASTE MANAGEMENT PRACTICES, STRATEGIES AND POLICIES

C&D waste management literature suggests three waste management strategies that are desirable: reduce, reuse and recycle. Even though these strategies are environment friendly and contribute to the sustainable development of a society, the construction industry is mainly driven by economic incentives (Begum *et al.*, 2006). Moreover, there are many other barriers that prevent the construction industry participants from carrying out practices that favour reuse / recycle. Hence, the government and policy makers in various countries enacted policies and adopted strategies that induced sustainable waste management practices in the industry. The quantity of C&D waste recycled out of the total quantity of C&D waste generated in some of the developed countries is shown in the Figure 1. It can be observed that the percentage of recovery is quite high in certain developed countries. The characteristics of the environment prevailing in those countries have certainly favoured the growth of the recycling industry. In this section, the practices, strategies and policies adopted in various countries has been reviewed.

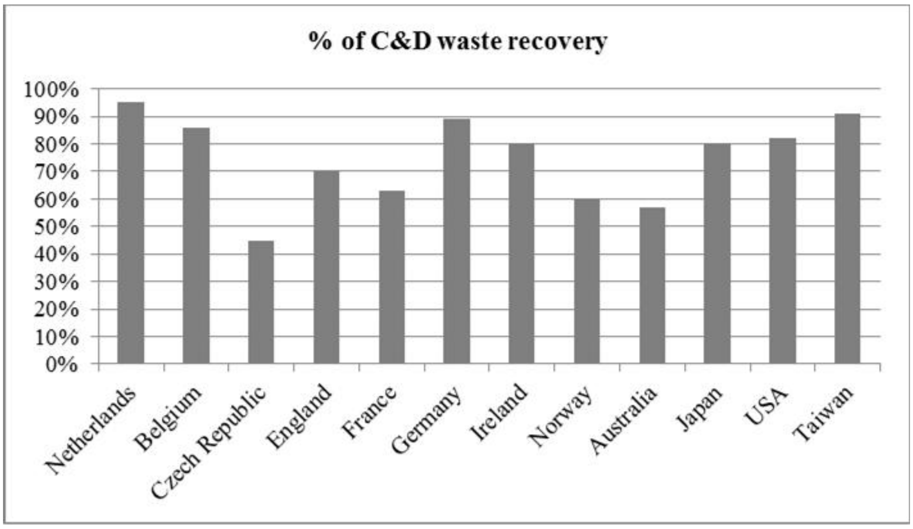

Figure 1: Percentage of C&D Waste Recycled Out of Total Quantity of C&D Waste Generated
Source: CSI (2009)

2.1. EUROPEAN UNION

European Union is estimated to be generating about 450 million tons of C&D waste annually and out of this, concrete and masonry debris alone constitutes around 180 million tons (Symonds, 1999). Among the EU countries, Netherlands, Belgium and Denmark are recycling more than 80% of the total C&D waste being generated every year. These EU countries have set up a target of 70% for recycling according to the Waste Frame Directive (2008/98/EC). The percentage of recycling showed an increasing trend in the other EU countries too (Engelsen, 2013). Till the late 1990s, the C&D debris were primarily put to use in non-structural applications such as engineering fill and road sub-base. In Netherlands, the landfilling of reusable C&D waste is banned throughout their country. Similar ban on land filling C&D waste were also noted in countries such as Belgium and Germany (Symonds, 1999). Although the land filling ban might not be the only reason for higher recycling ratios in these countries, it might have contributed a major part in achieving higher recycling ratios irrespective of the kind of use to which they have been put. Wherever landfill ban is absent among the EU countries, landfill taxes are high in order to discourage the land filling of C&D waste.

In order to enhance value of the C&D debris and use the recycled aggregates produced out of them in higher grade applications, the onsite sorting of debris is essential. Having acknowledged this, the selective demolition and onsite sorting of waste has been made mandatory in Norway and other Scandinavian countries (Engelsen, 2013). The specific set of guidelines for selective demolition and onsite sorting have been framed and enforced through the Norwegian Waste Handling Rules in Norway. The implementation and enforcement of this initiative helps in easier processing as well as in achieving high quality recycled product in an economically viable manner.

In Spain, the problem of illegal dumping of C&D debris at illegitimate places is addressed through a waste management model called as Alcores model (Jaime *et al.*, 2009). As per the model, the developer needs to deposit a certain amount of money with the local body depending on the type of work involved and furnish an estimate of the quantity of waste that might be generated. Later as the work begins, the developer must dump the waste at the recycling facility approved by the local body. In order to retrieve the deposit made, the developer must furnish a certificate issued by the concessionaire of the recycling facility certifying the compliance. The facility recycles the waste and the products are sold back in the construction materials market.

2.2. HONG KONG

In Hong Kong, it has been reported that around 20 million metric tons of C&D waste has been generated annually during the period 1993 to 2004 (Poon, 2007). Realizing the importance of the need for managing the waste in a way to reduce their impact on the environment, the Government of Hong Kong introduced a series of policies. Hong Kong adopted the polluter pays principle and enacted a waste disposal charge scheme and thereby encouraging better waste management philosophies such as reduce, reuse and recycle before disposal. Similar to Norwegian guidelines, it has also mandated the preparation of waste management plan for the contractors, wherein the contractors need to set their waste reduction targets and programmes accordingly before the commencement of site operations. Moreover, the practice of onsite sorting of waste is encouraged through a differential charging scheme based on the sorted nature of the waste at the point of disposal (Lu and Tam, 2013).

The government has developed three types of facilities which accept the waste from the waste generators as depicted in the Figure 2. A waste generator can send the waste to a landfill facility, an offsite sorting facility or a public fill reception facility depending upon the nature of the waste to be disposed of. The charges are high if the waste is disposed in landfills and minimum if it is disposed in public fill reception facilities. However, these facilities have rigid criteria on the type and composition of materials in the waste in order to accept the waste from the generators. For example, the offsite sorting facilities will only accept those wastes which are composed of at least 50% of inert materials. Moreover, a public fill reception facility will only accept inert materials such as sand, bricks and concrete which can later be used for land reclamation. The Trip Ticket System (TTS) was introduced in 2003 in order to prevent illegal dumping of C&D waste in Hong Kong (Lu and Tam, 2013). Through the TTS, the tracking and monitoring of waste is made possible thereby making it impossible for the transporters of the C&D waste to dump it illegally.

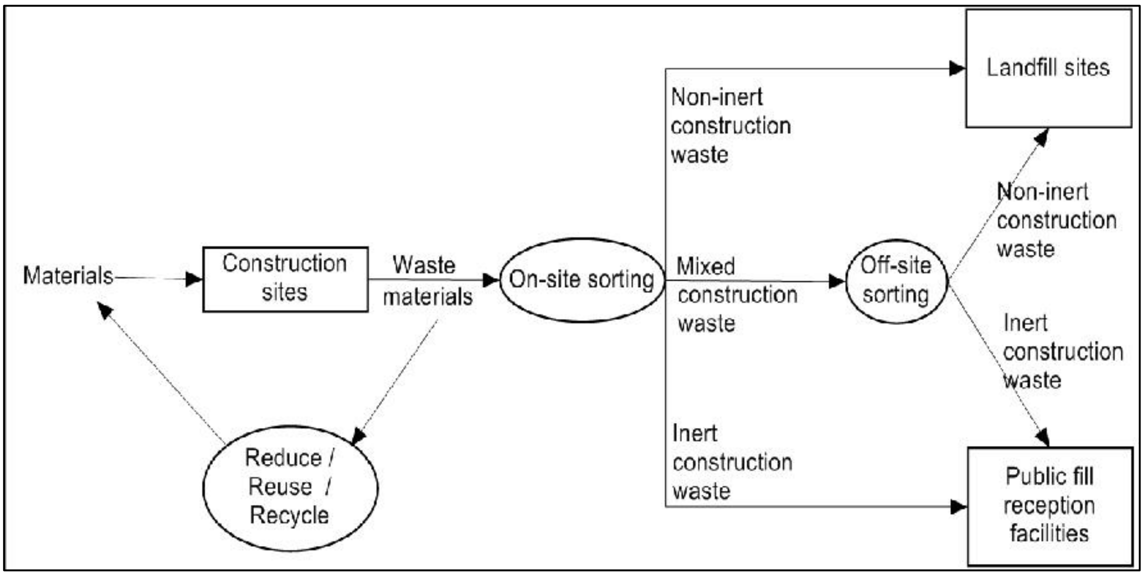

Figure 2: A Schematic Representation of Waste Management Plan of Hong Kong
Source: Lu and Tam (2013)

2.3. UNITED STATES OF AMERICA

In USA, the individual states have drafted and enforced their own regulations for managing the C&D waste stream. For example, The North Carolina Solid Waste Management Act of 1989 mandates the separation of C&D waste from the municipal solid waste. Moreover, the C&D waste needs to be further segregated into recyclable and non-recyclable materials. The inert wastes such as concrete, brick, soil, concrete blocks and gravel are required to be recycled and reused as fill materials (Duan *et al.*, 2015).

2.4. ISRAEL

In Israel, although there is a lack of legislation favouring recycling of C&D waste, the problem of illegal dumping of C&D waste is addressed through a vehicle impoundment (VI) policy (Seror *et al.,* 2014). The practice of illegal dumping has both environmental consequences as well as economic implications. In order to counter this practice, Israel Ministry of Environment Protection (IMEP) has empowered the inspectors of Green Police (the law enforcement division of IMEP) to impose fines upon truck drivers who engage in illegal dumping of C&D waste in open areas. Even after this initiative, the quantum of C&D waste getting illegally dumped did not reduce. Therefore, Israeli government sought to do vehicle impoundment, one of the common punishments adopted to prevent traffic violations. In Israel, through the enforcement of the VI policy to curb illegal dumping, the inspectors of the Green Police would be able to confiscate the vehicle of the offender on the spot for a period of up to 30 days without the need to bring in regular police force. This policy was found to be effective in reducing the quantum of illegally disposed C&D waste (Seror *et al.*, 2014).

2.5. JAPAN

In Japan, C&D waste is considered as a construction by-product instead of waste (Nitivattananon and Borongon, 2007). The incorporation of permission to use recycled aggregates produced from C&D waste in specifications and national codes is essential to gain acceptability in the market. In Japan, there was a progressive development in the standardization of usage of recycled aggregates. In 1977, Building contractors society framed a set of guidelines to help in quality control. The subsequent revisions were triggered by the research activities and the developments in recycling techniques. In 2007, Japan Industrial Standards Committee formulated three classes of recycled aggregates: Class H, Class M and Class L. The classification was according to the material properties of the recycled aggregates. The scope of application was limited with respect to the class of the aggregates. There is no restriction for use of Class H aggregates in concretes up to M45 grade whereas Class L aggregates were allowed to be used only in backfilling concrete and blinding concrete (Noguchi, 2012).

3. METHODOLOGY

A case study research methodology has been adopted in this study (Yin, 2003). A total of ten case studies have been conducted on randomly selected building demolition projects. The projects included demolition of three residential buildings, five commercial buildings and two institutional buildings. In terms of the type of construction, four of them were RCC framed structures and the rest were load bearing brick masonry structures. For data collection and analysis, information about the administrative procedures of the Corporation of Chennai, the urban local body governing the development activities in Chennai city was collected through interviews of the engineers of the corporation. Direct observation of the demolition process and transcripts of semi-structured interviews of the demolition contractors have been collated to prepare the case studies of demolition projects. Interviews were also conducted with the prospective recyclers to understand the barriers in setting up a recycling facility in Chennai city. Case studies have been analysed using open coding technique. Secondary sources of data such as newspaper articles and other publicly available data have also been content analysed to map the waste management practices.

4. DEMOLITION WASTE MANAGEMENT PRACTICES IN CHENNAI CITY

In this section, the current scenario of the various practices being adopted by the stakeholders of demolition industry in Chennai city has been discussed. The waste management practices in demolition projects have been categorized into three phases: Pre-demolition, Demolition, and Post-demolition phases and the predominant practices that have been observed in the each of the phases of demolition are summarized below.

4.1. PRACTICES DURING PRE-DEMOLITION PHASE

The Corporation of Chennai is the governing body for development activities in Chennai city. The corporation has a Town Planning Department that looks after the sanctioning of permits for all the construction, renovation and demolition activities in Chennai city. Chennai Corporation is divided into three regions namely North region, Central region and South region. Each region is again divided into five zones thereby making a total of 15 zones in Chennai city. Demolition applications are categorized into two types: demolition only permit and demolition & reconstruction permit. As the name depicts, the former deals with those permits where only demolition is sought and the latter deals with those permits where demolition proposal is accompanied with a reconstruction proposal.

In order to obtain a demolition permit, the following details have to be furnished with supporting documents: master plan of the building that is to be demolished and the details of the ownership of the building. There is a demolition fee that has to be paid to the Chennai Corporation in addition to furnishing the above mentioned details. Before sanctioning the permit, an engineer from the corporation visits the site and validates the details submitted. It is to be noted that the applicants are not required to furnish information relating to the amount of waste that might be generated during the construction / demolition activities and plans to manage that waste. Moreover, the details such as area of the building, type of materials used / to be used are not being explicitly documented. Such records would be very useful in estimating the quantity and composition of waste getting generated.

4.2. PRACTICES DURING DEMOLITION PHASE

The demolition technique adopted by most of the contractors closely resembles to selective demolition. Selective demolition is a technique in which each component of a building is carefully dismantled in order to facilitate reuse / recycle. As the demolition contractors bag the project by paying a lump sum amount to the owners, they try to recover the materials that have economic value through which they can fetch money in return for their investment. A typical residential building’s sequential demolition is discussed below.

Any building that has to be demolished will be stripped off its various components thereby leaving the frame of the building alone in its place. This can be seen in the Figure 3. Electrical wires are the ones that get immediate attention due to their high economic value as well as ease with which they can be removed. It has been estimated that the copper from these electrical wires fetches around 300 Rs/Kg. Aluminum from the electrical wires fetches around 40 Rs/Kg in the secondary market. Switch boards are carefully removed and sold. PVC pipes are also separated and sold in the secondary market.

The wooden doors and windows are removed and stacked separately during demolition as shown in the Figure 4. It was interesting to know that these wooden doors and windows are sold in the secondary market of Mumbai city which is approximately 1300 Kilometers from Chennai city. The point to be noted here is that the supply chain of secondary market has a very strong network across the country and the recovered materials are sold in those places where they fetch maximum revenue. The revenue depends on the quality of the wood and it is estimated that the superior quality ones can fetch as much as 150 Rs/ft^2 while the ones of inferior quality can fetch around 30 Rs/ft^2. Glass windows are also carefully separated and stacked for transport to the secondary market. Plumbing components such as PVC pipes, wash basins and metal / plastic taps are also removed and stored separately to be sold.

Figure 3: Salvaging Materials Having Economic Value

Figure 4: Recovered Doors and Windows

Once all the components and materials that have economic value are removed, the frame of the building composed of concrete and brick masonry (as shown in the Figure 3) remains in its place. The frame of the building is then demolished either using hydraulic breakers or manually using hammers and rods. Since the latter method consumes a lot of time, it is employed only in the case of small residential buildings mainly made of brick masonry. Hydraulic breakers are commonly adopted in other cases as the work can be completed in few hours. Almost all of the projects that are studied, with an exception of a few, have employed hydraulic breakers to demolish the frame of the building. In all of the cases studied, the debris such as brick masonry, concrete, plaster and paint were never separated from each other while demolishing the building.

4.3. PRACTICES DURING POST-DEMOLITION PHASE

After demolishing the building using breakers/hammers, the reinforcement steel used are also recovered from the debris with the help of gas cutters. The process of salvaging steel from the debris is laborious and also time consuming. However, the economic incentive is high enough for the demolition contactors to adopt the process of salvaging. The concrete and masonry debris that remains at the site has a seasonal value attached to them. During rainy seasons, they are found to be in demand in low lying places. Some construction sites collect the brick masonry debris to be used as the base material for site access roads. However, it has been found that the debris getting dumped in either legitimate or illegitimate disposal sites is predominant. Moreover, the quantum of debris getting dumped in the legitimate disposal sites is small and a huge fraction of them is found to be dumped on road sides, parks, canals and marsh lands. This type of illegal dumping affects the ecosystem severely and gives a negative image to the solid waste management system of the city. There have been many articles in the newspapers addressing the issues mentioned above. As the Chennai Corporation handles solid waste management in the city, the debris that are illegally dumped, are collected and transported to landfills located in Kodungaiyur and Perungudi.

C&D debris are voluminous in nature and hence, they occupy a large space in the landfill. The Chennai Corporation incurs huge expenses, both for transporting the debris to the landfills as well as for land filling them. The problem for Chennai Corporation is not only that it incurs costs for waste disposal but also that the landfill spaces are getting depleted at a rapid pace owing to land filling this voluminous debris. Hence, there is a pressing need for an alternative solution to debris disposal. However, the C&D debris recycling facilities are not available in Chennai city. The barriers that prevent the setting up of C&D debris recycling facilities and the usage of recycled aggregates are discussed below.

5. BARRIERS FOR RECYCLING C&D DEBRIS

Recycled aggregates (RA) could be produced from C&D debris by crushing the debris and size classification using sieves in a similar manner by which natural aggregates are produced from quarried rocks. The composition of C&D debris is one of the many factors that affect quality of the recycled aggregates. The quality of RA produced from concrete debris is relatively high compared to those produced from mixed debris containing both concrete and masonry debris. The quality gets affected also because of the presence of old mortar getting adhered to the surface of RA produced. The technology used for the production of RA influences the amount of mortar adhering to the surface of RA. Predominantly, the RA produced have been put to use in non-structural applications such as engineering fill and road sub-base materials. In the recent years, the trend of quantity oriented recycling has shifted towards quality oriented recycling in many of the developed countries and the recycled aggregates produced are being used in structural applications also. However, there are very few recycling facilities available in India to produce recycled aggregates from C&D debris. Based on the ten case studies and numerous interviews of the demolition contractors and Chennai Corporation personnel, the barriers for the setting up of C&D debris recycling facilities have been identified and are discussed briefly below.

Lack of awareness **-** The awareness of the recycling possibilities of C&D debris is very low among the stakeholders. Even the TIFAC survey reported that around 70% of the people surveyed were unaware of the recycling possibilities and around 30% were not aware of the recycling techniques that are available to produce aggregates in a cost-effective manner from C&D debris. The lack of awareness on the environmental implications of using natural aggregates has also been attributed to the lack of recycling initiatives in the Indian urban areas (Rao *et al.*, 2006).

Unavailability of reliable estimates **-** There are no reliable estimates available on the quantity of C&D waste getting generated in the Indian urban areas. Unlike some local bodies in developed countries, there are no records available with the Chennai Corporation containing details regarding the quantity of waste generation from C&D activities. As this estimate is crucial for planning the capacity of recycling facilities as well as formulating the policies and strategies that can orient the practices towards reuse / recycle, generating estimates needs to be one of the top priority steps towards sustainable C&D waste management. The records of details regarding the quantum of C&D activities occurring in the region would prove useful in generating estimates and the urban local bodies need to augment their existing system to facilitate such documentation.

Prevalent illegal dumping **-** The practice of C&D debris disposal in unauthorized places such as road sides, public parks, canals and marsh lands is prevalent in Chennai city. The problem of illegal dumping is not specific to Chennai city and has been reported to be occurring in various countries worldwide. This practice affects the economic viability of recycling the debris as the costs for collection and the associated transportation from illegal dump sites to recycling facility becomes substantial. In Chennai city, there is a fine of Rs. 2000 imposed upon those truck drivers who are caught in the act of illegally dumping C&D waste. However, the fine is not adequate enough to deter this practice and there is a dire need for the revision in this fine structure. There is a need for more stringent action towards violations in order to curb this prevalent practice. Moreover, the enforcement needs to be strict and severe punishments for violations have been reported to be effective in addressing this problem. The policies that have been found to be effective in other countries to minimize illegal dumping could serve as guidance while enacting one for the local scenario.

Quality of recycled products - Any recycled product is expected to perform as its primary counterpart. Since recycled concrete aggregates are produced by crushing concrete debris, there is a layer of porous cement mortar that remains adhered to the surface of the recycled aggregates (Rao *et al.* 2006). This adhered mortar renders the recycled aggregates into a substandard quality as compared to the natural aggregates owing to increased water absorption and inferior mechanical properties comparatively. The quality gets worsened if the constituents of C&D waste were not pre-sorted. From the case studies, it has been observed that the debris were all mixed together and the practice of onsite sorting of debris was absent. This can prove to be a significant barrier as it influences the acceptability of recycled aggregates. The practice of on-site sorting of debris could also help in reducing the cost of producing good quality recycled aggregates and thereby imparting economic viability. Therefore, the enforcement of certain demolition guidelines that could induce such practices among the demolition contractors is needed in order to enhance the possibilities of C&D debris recycling.

Lack of government support - Profitability of C&D debris recycling is observed to be one of the major concerns among the prospective recyclers. Lack of appropriate regulations and policies that enhance the economic viability of recycling is observed. Moreover, the demand for recycled aggregates in the market is unknown which leads to a considerable amount of risk perceived in setting up recycling facilities. The presence of government support in terms of incentives and policies could serve the establishment of recycling industry. The recycling facility in New Delhi was also established with the aid of government in terms of low lease rates for land and tipping fees for collection and transportation of C&D debris from the collection centres to recycling facility.

Acceptability of recycled aggregates - It has been observed that the usage of recycled aggregates was not explicitly allowed in the 'Indian Standard Specification for Coarse and Fine Aggregates from Natural Sources for Concrete' (IS 383-1970). Many developed countries have framed specifications for the use of recycled aggregates produced from C&D debris and have incorporated them in their codes and standards too. While there is a need to set up recycling facilities to produce recycled aggregates, the permission to use the recycled aggregates through standards and specifications could certainly boost the rate of development of such facilities and the acceptability of recycled aggregates in the market will also be enhanced.

6. DISCUSSION

From the study, it can be observed that waste management practices can have a substantial influence on all the three stages of C&D waste recycling: collection, processing and utilization. In the Indian urban areas, there are no reliable estimates available regarding the quantity of C&D waste getting generated (CAG, 2008). The statistics available in several other countries shows the extensive amount of surveillance on the C&D waste stream which is lacking in India. The unavailability of the estimates has kept the C&D waste stream in the dark and the situation demands a change in the system. The urban local bodies need to augment their documentation in order to record the data regarding the C&D waste getting generated and thereby can facilitate in estimating the total quantity of waste generation. The review of international cases has shown that the policies and strategies adopted have induced sustainable practices among the stakeholders of the construction industry.

The development of appropriate incentive mechanisms and supporting infrastructure in Hong Kong and other countries have favoured the practice of on-site sorting of waste. However, in India, C&D waste often gets mixed with municipal solid waste and constrains the economic viability of recycling significantly. Moreover, the prevalent practice of illegal dumping observed in Chennai city must also be countered. Some innovative strategies such as vehicle impoundment and Alcores model from Spain could be evaluated for implementation in Chennai city in addition to levying fines from the truck drivers indulging in illegal dumping. Moreover, several countries have restricted the type of waste that can be disposed in landfills stressing the need to conserve the natural resources. Recyclable materials must not be allowed to get dumped in landfills in order to bring a change in the mindset towards conserving resources among the stakeholders. The traditional practice of land filling the C&D waste needs to be changed in Chennai city. The Corporation of Chennai has to play an enabling role and the international success stories can serve the local body in establishing an effective system for managing C&D waste in Chennai city.

7. SUMMARY AND CONCLUDING REMARKS

A review of international practices, strategies and policies of several countries which aligned the waste management practices towards the growth of C&D waste recycling industry is presented. Based on the case studies on demolition projects in Chennai city, it was observed that the practices adopted in demolition projects were purely driven by economic incentives without taking environmental effects of such action into consideration. A widespread practice of unauthorized disposal of C&D debris in road sides, canals and other water bodies was observed. Lack of awareness of recycling possibilities of C&D debris is found to be one of the major reasons for lack of recycling initiatives in Chennai city. Some of the other barriers for the setting up of C&D debris recycling facilities are lack of reliable estimates, absence of government support, practice of illegal dumping, absence of on-site sorting of debris and lack of standards for the usage of recycled aggregates.

To conclude, there is a need for appropriate policies and strategies in order to induce sustainable waste management practices in Chennai city. Once the waste management practices are aligned towards sustainability, it will greatly enhance the amount of C&D waste recovery in India. Since the lack of reliable estimates needs to be addressed as the first step, the future work of this study aims at developing an estimation model that better fits the local scenario. The data regarding the quantum of C&D activities occurring in Chennai city will be collected and the quantity of C&D waste getting generated will be estimated. The strategies and policies that are needed to enhance C&D waste recovery in the local scenario will also be studied in the future.

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