Study On Reverse Logistics of Demolition Waste Management

Joel.S.S[1], Dr.T.R.Sethuraman[2]
[1]*Student, ME II year, Department of Civil Engineering, Sivaji College of Engineering and Technology, Manivila.*
[2]*Faculty of the department, Department of Civil Engineering, Sivaji College of Engineering and Technology, Manivila, Kanyakumari District*

***Abstract*–With the ever-developing world, construction activities are the forefront indicators of progress and economic growth. This leads to the creation of big cities along with the supporting infrastructure. But as time progresses, new and more efficient systems and technologies arise along with the ever-increasing population and the need to cater for their necessities. The inevitable passage of time and this need for expansion especially in space limited environments necessitate the decommissioning and demolition of existing structures as they cannot be reasonably upgraded for new needs or is degraded to a point the serviceability is reduced below requirements. This calls for the process of engineered demolition. It solves the problem of decommissioning the old structure, creating space for new ones and eliminating the hazards of degraded structure all at once. This study focuses on the topic on demolition waste management and the application of the concept of reverse logistics in demolition management. Reverse logistics aims to find the solution for waste generated during demolition activities while promoting the ideas of sustainability and resource recycling on a practical level with very less to no additional cost. This study aims to analyse multiple researches including case studies, theorized concepts and related content to explain about the factors involved in demolition process, waste management and the use of reverse logistics in all of that.**

***Keywords*–Demolition waste, Reverse logistics, Recycling, Reuse**

I.INTRODUCTION

The construction industry often involves a lot of simultaneous operations at once to achieve a single task. The same is true for demolition operation as it is an extension to the construction industry as a whole. Afterall the key objective of the construction industry as a whole is to provide the society with amenities like housing, transportation, and other infrastructure. Demolition operation and in specific engineered demolition is one of the necessities with the passage of time an effective method to deal with the problem of old, residual and sometimes threats caused by otherwise obsolete structures.

Demolition unlike construction is a destructive process. And for that reason, this process creates a lot of material that can and cannot be reused in varying capacities. Such collected and salvaged items will be termed as demolition waste and demolition debris. These materials cannot be treated like other waste materials since some of them could fetch a decent price back, while others can become hazardous. This creates a need for the professional handling of construction waste and related equipment and materials. An easy solution to this problem is to use the concept of reverse logistics to manage the waste produced during the demolition operation. A success in establishing such a logistic route would give an effective route for waste disposal, compliance with environmental protection guidelines and to get some money in return.

II. OBJECTIVE

The aim of the project is to study the possibilities and advantages of using the concept of reverse logistics in the field of demolition waste management. This study aims to analyse various materials obtained by demolishing a building and study how they are treated and then use insight to rank each item on the basis different criteria. All of these ranks help to understand how well they would perform when or if they are put back into the supply chain in the form of reverse logistics.

III. METHODOLOGY

This research is based on the data collected from face-to- face interviews and site visits with a few industry professionals, engineers and dealers. Data was collected from those sources and is elaborated as much as possible. The collected data is then classified in to several ranking criteria to quantitatively assess each factor contributing to the reverse logistic potential of each studied item. Due to the difficulty in accounting for the variations in each material from different studies, a ranking system is used here to quantify and explain about each material.

IV. LITERATURE REVIREW

From this brief study of a few literatures, it was found out that construction demolition waste management is an actual concern in the construction industry. In most cases without other intervention, the most common solution followed was using demolition waste as landfill. Multiple studies found the feasibility of a reverse logistic system being effective in managing demolition waste. Some studies did case studies and field experiments further reinforcing this claim. Some studies also suggested methods to promote industries and governments to effectively manage construction and demolition waste in an environmentally friendly and sustainable manner.

V. ANALYSIS OF DATA

After the collection of data from various sources it was found that the nature of construction and demolition waste management varies by a lot due to numerous involved factors. The two main factors that this study is based upon is the scale or scope of the project and the type of material involved. In addition to demolition waste management, this study also includes management of waste generated during the construction projects. This study explored the practices of waste management from the perspective of implementing reverse logistics while studying and acknowledging the current practices that are in place. It is noted that some of the practices that are already in place are much more effective and often times more economical than implementing a system that is new and alien to the workforce and management involved. This study also aims to explain the interesting concept of an indirect reverse logistic chain that effectively is already in existence and in use which was found in multiple occasions.

A. Influencing Factors

The scope of waste management depends upon the scope of the project. Since it is dependent on the overall budget of the project, there will be direct consequences to each and every decision taken regarding the management of waste materials. Key points which are influential to the success of a waste management system are noted and discussed below:

1. Budget

Budget in this particular context means the amount of money allocated for construction and demolition waste management. For a large-scale construction project, there would be an allocated budget for demolishing an existing structure before clearing and preparing the ground. For a small-scale project where demolition of an existing structure is necessary, it is also observed that budgeting is also done for demolition and waste management resulting from the demolition.

In terms of managing waste generated during construction, large scale projects do have a dedicated budget to cover for the site cleaning at frequent intervals sometimes with dedicated staff to not interfere with the workflow. This is even applicable for site clean-up after the completion of the main structure. For small scale projects, there will not be dedicated budget or clean-up staff during any stage of the process. Due to the limited scale needed, the budgeting will be covered under lumpsum expenses.

2. Scale of the Project

For a small-scale project demolition waste does not possess much of a concern since it can be managed locally and with relative ease. Since the waste produced will not be beyond the scale of capability of the contractor, it will mostly be manged by the building construction team itself. On many occasions, there will be materials from the old structure that can be transferred over to the new structure or it something like concrete waste can be repurposed for stabilizing material or to raise the ground if needed.

In case of a large-scale project, situations are far more different than a small-scale project. Often times, demolition of larger scale building are conducted only at the end of their life cycle. There may be refurbishments and repairs done to the structure to extend the life beyond the initial design estimates. These may lead to an extremely unstable and deteriorated structure by the time it will be scheduled to be demolished. Also due to the size of the building the waste generated will be tremendous. Therefore, dedicated facilities and budgeting will be needed for managing waste generated during such demolitions. And these have to be specific in the sense that it has to be made such tat there will not be any impact on the upcoming construction project or the surrounding area.

3. Material Used

Scope of reusing or repurposing of demolition waste depends upon the nature of material used in the construction. Some materials can be salvaged but cannot be reused without processing, while some materials can be repurposed without any modification. There are also materials that are not fit for reuse in any form or cannot be safely extracted.

Discussed below are few examples under each category of material. Materials made with or have similar properties to concrete or stone like floor tiles, concrete blocks, RCC structural members cannot be property salvaged because removing it require destructing them. Materials made with metal including window panes, frames, doors can be reused or sold as used commodities, while reinforcement bars can must be recycled as it endured stress during the service period and have undergone deterioration.

4. Salvage and Scape Value

Salvage and scrap value depends upon the ease and effectiveness of reusing and recycling demolition waste. The item with highest scrap or salvage value will be metal articles. Depending on the use case during its service period, it can be recycled or reused. Metal is also infinitely recyclable. For this reason, there will always be a high value for metal in construction. Meanwhile items like concrete rubble have zero salvage or scrap value since it cannot be reused or recycled other that a few limited applications. Such a disparity in the value of items post service life poses a difference the way each material is handled.

5. Transportation facility

The scale of a waste management strategy is often decided by the scale of transportation facilities available. For areas with adequate transportation facilities, waste management will not be a difficult task. This facility provides them to ship their demolition waste to treatment plants or to people who specializes in particular waste treatment.

For locations with limited or expensive transportation facilities, waste management strategies have to be strategic and it will be suitable to do it on site rather than shipping it elsewhere. Onsite waste management often have measures to transport waste to shorter distances for a safe disposal, but the management team have to be strategic with their approach.

6. Rules and Regulations

Rules and regulations mean the policies and standards set by the governments and local governing bodies regarding management and disposal of construction and demolition waste. These do vary a lot depending on the location. This directly corelates to which method the project has to follow for waste management.

There are also policies related to certification and accreditation agencies like GRIHA or BEE. Some projects also require clearances from bodies like police or fire and rescue. Compliance with all of these require following a specifically defined set of practices and methods in order to get proper operating permits and licences.

7. Incentives

Incentives refer to the financial or other aids received by the project regarding their particular practices followed on demolition waste management. An incentivised system promotes the proper adherence to procedures and standards even without any enforcements. Certain dealers who specialize in dealing with particular kinds or waste materials would often provide incentives in the form of commissions or gifts to attract more quantity of items to be channelled through them. Such practices are good for all the parties involved.

8. Demolition vs Dismantling

Demolition refers to the practice of deconstructing a structure using a completely destructive process while dismantling is a controlled deconstruction practice that aims to remove the building by parts without damaging them so that they can be salvaged to obtain items or value. The choice of deconstruction affects the complexity, time and effort required for the job. The process of demolition is relatively simple and straight froward, in the sense that the entire building is destroyed to make space for the new one. The process of dismantling is much more involved in the sense that it requires more care to properly and carefully disassemble each possible component so that it can be repurposed or reused or salvaged.

B. RANKING AND CLASSIFICATION

This section aims to quantitatively analyse the data obtained from the site visits and case study analysis conducted thus far and present it in a quantitative manner to reach conclusions from this study. This section contains ranks and discusses about different waste material collected and the finally discusses about the reverse logistic potential of each material based on the different factors.

1. Waste Material Generation Quantity

The amount of waste material generated and the quantity of each kind of material that was generated varies depending on the site under consideration. But the following table shows the amount of type of waste generated on all the sites based on a ranking system since it is difficult to analyse the precise percentage of generated. The results are as follows:

Ranking of Waste Material Quantity Generated	
Material	Ranking
Concrete / Brick	1
Steel from reinforcements	2
Wooden Fixtures	3
Metal Fabrications	4
Ceramics	5
Plastics	6
Furniture	7
Electrical Fittings	8
Plumbing Fittings	9
Glass	10

Table 4.1 Ranking of waste material generated

The above table was constructed based on the data collected during the study. As it implies the most amount of demolition waste was generated from concrete or brick related items. This includes RCC members and brickwork. This is directly the resultant of concrete being the key material used for modern construction.

In addition to being ranked first in generated quantity, concrete waste constitutes more than 90% of the total waste generated. All of the other materials combined will make the less than 10% volume of the entire demolition waste generated.

The least found material in demolition waste during the study was glass and glass related articles. Glass is often preferred as a decorative material with almost no structural applications. This limits the application of glass to a minimum resulting in the least obtained material from a demolition waste collection

2. Resale Value

Resale value refers to the sum of money that can be obtained by selling the demolition waste to the respective resource centres. In most cases these will be scrap dealers or landfills. Since the accurate amount of money varies a lot due to several factors, a ranking system is used for this classification.

Resale value of Demolition waste	
Material	Ranking
Steel from reinforcement	1
Electrical Fittings & Wiring	2
Furniture	3
Metal Fabrications	4
Plastics	5
Wooden Fixtures	6
Plumbing Fittings	7
Ceramics	8
Concrete / Brick	9
Glass	10

Table 4.2 Resale value of demolition waste

Note that these rankings are provided based on the resale value of the materials as is and not after refurbishment or recycling. The value of the item varies based on the condition of the individual items and quantity at which it is sold at. The above rankings are given based on the general trends and assuming realistic wear and tear.

Steel from reinforcements is ranked first due to the desirability of steel among scrap dealers. This is due to the fact that metal articles are infinitely recyclable. Other items such as metal fabrications and electrical items are valued lower due to the wear and tear on them.

3. Reuse Potential

Reuse potential refers to the value of a material by using them again after being taken from a demolished building. This does not include recycling, rather it focuses on refurbishing and repurposing or using it as is without any modification.

Reuse potential of Demolition Waste	
Material	Ranking
Furniture	1
Metal Fabrications	2
Wooden Fixtures	3
Electrical Fittings & Wiring	4
Concrete / Brick	5
Steel from Reinforcements	6
Plumbing Fittings & Wiring	7
Plastics	8
Glass	9
Ceramics	10

Table 4.3 Reuse potential of demolition waste

The most valued item on the list as reusable is furniture items. These include items that provide amenities. Examples of furniture discussed here includes tables, beds, shelves, etc. These items have a high reuse potential due to them being made from higher quality base material. Most furniture items are also well handled and maintained compared to other items on the list.

Lowest ranked item on the list is ceramics next to glass. This includes floor tiles and sanitary fixtures like toilets. Items like ceramic floor tiles can only be removed by breaking or shattering rendering it completely useless. Same is true for most glass items. For these reasons they are ranked at the last positions of the list.

While not being at the top of the list it is important to mention the reuse potential of used electrical items and concrete. Due to the wide availability concrete is the most popular and cheapest material for land filling. This is particularly helpful in land development applications since concrete waste can be dumped and compacted to raise the ground level.Electrical items do undergo wear and tear due to normal usage but they will not get completely damaged. For this reason, refurbishment services accept used electronics and sell them to the market at a reduced price to the market. In some situations, the new building will carry over some of the old electronics like stoves, air conditioners and refrigerators after reconditioning them.

4. Recycling potential

Recycling potential refers to the ability of a material to be recycled and put back into circulation in a different form.

Recycling potential of demolition waste	
Material	Ranking
Steel from reinforcements	1
Metal Fabrications	2
Electrical Fittings & Wiring	3
Glass	4
Plumbing Fittings	5
Plastics	6
Furniture	7
Wooden Fixtures	8
Ceramics	9
Concrete / Brick	10

Table 4.4 Recycling potential of demolition waste

Recycling potential is an important factor to be considered in choosing construction material as it impacts how the structure is managed after being demolished. The item with the highest recycling potential is metal made items including reinforcement steel members, fabrications etc. due to the fact that metal can be recycled even if it is severely deformed or damaged making it unusable or it has failed due to high amounts of stress, its value in recycling sector is always considered high.

Items like wood concrete and ceramics cannot be recycled due to their chemical structure, as they would breakdown upon processing and it cannot be repurposed further. This makes them rank low in recyclable value comparison. This factor directly depends on the value of these items on the recycling market. Since they have no recycling value, no dealer would accept these items for recycling purposes.

5. Acceptance Factor

Acceptance factor	
Material	Ranking

Steel from reinforcements	1
Electrical Fittings & Wiring	2
Metal Fabrications	3
Furniture	4
Wooden Fixtures	5
Concrete / Brick	6
Plastics	7
Plumbing Fittings	8
Ceramics	9
Glass	10

Table 4.5 Acceptance factor of demolition waste

Acceptance factor refers to the level of acceptance people have in accepting a waste article obtained from demolition to be processed further. This may be influenced by a lot of factors including logistics, demand, facilities, transportation, emotional reasons, local conditions etc. Higher the acceptance value of an item, the market value of that item will also be higher. Top section of the list is populated by metals and metal made objects. This is due to the resale value of metal – even deformed metal has a respectable resale value since it can be recycled. The lower part of the ranks contains items like glass and ceramics – items that would degrade or brake over time. This reduces their acceptance as they would become a burden on the handler if they cannot be passed onto the supply chain.

6. Reverse logistic potential

Reverse logistic potential is the combined effect of all the matters discussed so far. This rank provided below shows high likely a material is to be put back into the supply chain either for reuse or recycling – while giving importance on reusing.

Reverse Logistic Potential	
Material	Ranking
Furniture	1
Metal Fabrications	2
Wooden Fixtures	3
Electrical Fittings & Wiring	4
Concrete / Brick	5
Plumbing Fittings	6
Steel from reinforcements	7
Plastics	8
Glass	9
Ceramics	10

Table 4.6 Reverse logistic potential of demolition waste

From the study, furniture items were found to be having a higher rank on reverse logistic potential. This was found to be as such due to the minimal amount of effort required to put back a furniture item into use from a demolished building. In most cases, good quality materials are used to make furniture and they are often the best maintained commodities in a building.

Fixtures and fabricated items from a building along with electrical items from a building can be salvaged without damage prior to demolishing the building. This makes them fit to be used again if minor wear and tear are to be overlooked. Since they provide functionality to a building, they are kept maintained in working order. For this reason, they can be put to market somewhat easier.

Concrete waste is the most abundant material to come out of a demolition site. This material is not easy to manage due to the sheer quantity and the properties of concrete waste. The only way to manage concrete waste is to use it in landfills. This is especially useful when raising ground level for construction.

Glass, plastics and ceramics comes last in this list. Not because they are worthless, but they cannot be easily put back in a supply chain. Glass and plastic needs to be recycled and ceramics need to be handled carefully to prevent injuries. For a material or object that have no actual purpose once salvaged and have high risk of handling – ceramic is listed at the bottom of this rank list.

VI. CONCLUSION

A. General Conclusions

- There are already direct and indirect chains of reverse logistics in effect.
- Effective use of already existing supply networks like scrap dealers, refurbishes and resellers are the most effective methods to execute a reverse logistic chain.
- The demolition waste produced in highest quantity was found to be concrete or brick rubble.
- Best method of reverse logistics is found to be reusing followed by refurbishing and recycling.
- Certain materials like concrete cannot be

reused but can be introduced back into supply chain as landfill material.

- Resale value, scrap value and reuse potential decide how well an item behaves when introduced back into a supply chain.

B. Recommendations

Construction projects and practices will always evolve with the improvements in science and technology. New and refined practices and materials will be introduced to the market on a constant basis. In this economy, price fluctuation is not preventable. Establishment of a reverse logistic network help to combat this issue by making use of materials that would otherwise be discarded without consideration. Some recommendation to improve this process are pointed out below.

- More robust and well-built products are recommended in initial purchases, so that they would fetch a reasonable resale value and can be sold without scrapping.
- Creating a wider network of scrap dealers and waste management entities encourage end users to properly handle their demolition waste.
- Educating end users about recycling and reverse logistic practices is important to prevent mindless burying of every demolition product as landfill.

C. Future Research

This project was conducted based on the data received from a small number of sites and dealers. The scope and extend of this study can be broadened with larges sample sizes along with wider study area in future studies. Future detailed evaluations on this topic will result in valuable insights on resource conservation and effective implementation of reverse logistics in various fields other than construction and demolition. Further research can be done to spread knowledge about these practices to the general public and industry professionals to try out and participate in reverse logistic model of waste management in their respective fields.

DECLARATION OF CONFLICT INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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