Waste Construction Management in Social Housing Projects

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ABSTRACT: The construction and demolition waste in many ways impact the environment: They pollute the soil, the water, and the air. They change the landscape among other degradations of the ecosystem. Chile generates over five and a half million tons of construction and demolition waste a year. This figure represents about 10% and 30% of the total urban country waste. Although in Chile there isn´t an appropriate normative or law to regulate this type of waste to lead to a right arrangement in terms of waste.

This study presents an arrangement plan of construction and demolition waste to build Social Housing based on the constructive chasing of social housing done in Santiago, Chile. To do that, the main constructive waste generated were first identified, then the registry of quantity about the typology of material, also the national normative of management and the possible alternative of waste management based on the valuation of reusing, recycling and energetic valuation. The waste management plan looks for recovering the economic value and the usefulness that those wastes could have of which waste might shock negatively on our environment.

The study gives advice, responsibility, and actions that should be taken by the different constructive actors. On the other hand, the environmental and the economic impact are determined to the respective constructive enterprise. It also hands over the present normative of construction to implement this plan.

Keywords: wastes, residues, social housing

INTRODUCTION

The slums have been an issue worked out by the Ministry of Housing and Urban (MINVU) in Chile.

Nowadays, there are more than 30,000 families living in camps across the country. In 2011 there were more than 5,000 delivered home buying subsidies and it is expected to terminate about 700 existing camps in the coming years [9]. The solution was the creation of social condos with basic habitability conditions that families did not have before.

Social condos represent an important percentage of the Chilean housing park. MINVU estimates that more than 1 million people are living in them, and they are still growing in population. For this reason, it is worth questioning the waste quantity that will be generated and what to do with it.

In this respect, figures of the Ministry of Environment (MMA), indicates that in the year 2009 5,821,000 C&D waste tons were generated in Chile [10], a number that will continue growing because of current housing park conditions.

Construction companies have no legal obligation to implement plans or management systems to mitigate waste production. According the Regional Ministry of Health Service, in the Metropolitan Region (RM) 60% of C&D wastes are deposited in illegal dumps and in many regions landfills and dumps don't admit C&D waste because they reduce their useful life and are already saturated [8].This situation complicates the production and destiny of waste in Chile.

Taking an international example, in The European Union (EU), there is an annual generation of 450 million tons of C&D waste [3], but this is given in a context in which exists a community of nations that have a special C&D waste legislation. Broadly they have the obligation of segregate dangerous waste, classify waste, and separately collect toxic waste [13].

Considering the Chilean situation inside the international context, it is necessary for the national sustainable development to generate a waste construction management in social housing projects. Nonetheless these social constructions are low budget projects, this means low quality materials and some workers without specialization or with low experience. Therefore, before starting a waste management proposal, an on-site social housing site must be known. For this reason it was realized that a four month monitoring construction project of social housing was needed in Santiago, Chile.

Also this study provided labor tabs, each one with the task work description, waste generated, and its destiny. Pieces of brick and cement bag wastes are quantified too. The above information, besides the bibliography investigation, resulted in a waste construction management in social housing projects. This plan will lower overhead costs because it will

lower the waste evacuation and, in consequence, also the environmental impact.

GENERAL CONCEPTS

C&D Waste: Construction and demolition (C&D) materials consist of debris generated during the construction, renovation, and demolition of buildings, roads, and bridges. C&D materials often contain bulky, heavy materials, such as concrete, wood, metals, glass, and salvaged building components [14].

Reduction: First action in the waste management, consist in reducing the waste production inside the material life cycle.

Re-use: Recovery of waste or material present in them, for use in its original form as a raw material substitute in the production process that created it. [6].

Recycling: Recovery of waste or material present in them, for use in its original form as a raw material in the fabrication of other different products [6].

Heat Recovery: The waste energy recovery, consist in use of waste as energy source for the productive process without danger for the human health and without environmental damage [5].

Composting: Consist of biochemical decomposition of organic waste and can be used as fertilizer for agriculture, landscaping, erosion control and land recuperation.

BACKGROUND

Background in Chile

By the year 2009 the construction produced 5,821,000 C&D tons of waste, this is 34.4% of all the primary waste generated the same year. Fig.1 shows a report associated with the generation of C&D waste in Chile between the years of 2000 and 2009 elaborated by the former Chilean environmental commission.

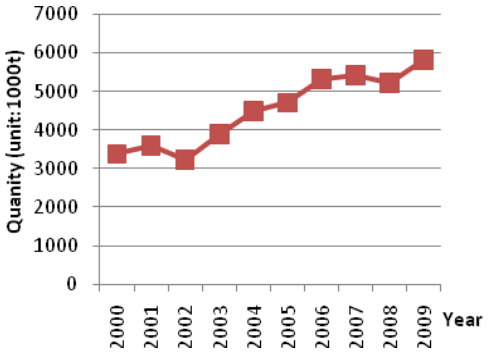

Figure 1: Waste generation levels in Chile [10]

On the other hand, a study realized by the National Council of Cleaner Production shows that the construction's solid waste evolution decreased 33.3% from 2000 to 2005, that is to say from 0.15m3/m^2 constructed to 0.05m3/m^2 constructed [2]. This decrease can be explained by the implementation of a Clean Production Agreement between 51 construction companies in the year 2000. Its effect lasted up to 2005, however some companies continue with these policies of environmental protection until these days, and also served to raise awareness in the private world around the construction waste. Nevertheless with the above, there is still a high tendency to generate large volumes of C&D waste.

With respect to the usual construction waste composition, the Chilean construction company TECSA indicates that its construction wastes are mainly composed of aggregates, cements, bricks, plastic coating and various materials, Fig. 2 shows it.

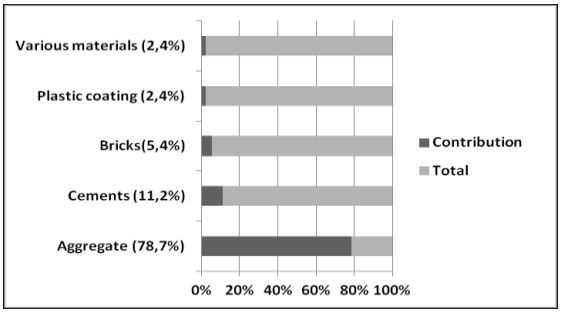

Figure 2: Construction waste composition [8]

Projected social housing

As mentioned in the introduction, there is a housing deficit because the large number of families living in camps. However, social condos represent an important percentage of the housing stock for social housing, it`s estimated that more than 1 million people live there. For example, just in Metropolitan Regions, there are more than 600,000 families dwelling in social condos [9].

Between the years 2006 and 2010 the average of given solutions was 1800 annually and it`s expected that the Comprehensive Plan of Camps of the current government hope to reach 9,000 solutions in the year 2012 [4]. These figures are an indicator of the social housing construction growth; this means an attractive sector to do a big scale waste management with a real impact.

Current and future regulations

There are some regulations today, but they are scattered and incomplete. For the normative, C&D waste is industrial waste. Also, there is a sanitary regulation of dangerous waste; this regulates its operation, allowing to improve the authority´s control and force the creation of management plans.

Today, the Metropolitan Region has the Regulation N°5081/93 from the Service of Health Metropolitan. This regulation establishes a system for tracing of

industrial solid waste. Also, there is a specific normative. For example, the absolute prohibition of throwing debris and waste into the ocean.

ISO management system also exists; they are not an obligation but are a valid way for waste management. For example ISO 14.001 (environmental management system) and ISO 9.001 (quality management system).

Specially noted is the Clean Production Agreement (APL). This consists of an agreement between the business sector and public organism. Its objective is to apply a clean production through goals and specific actions. Figure 3 shows simplified scheme of production in APL.

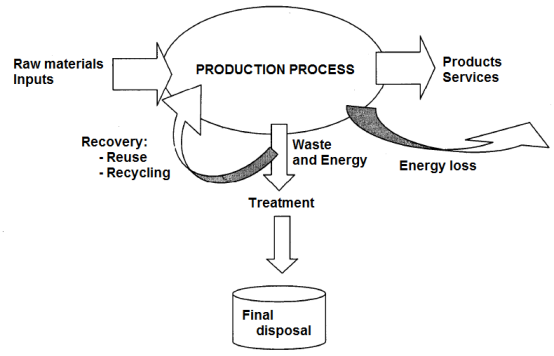

Figure 3: Simplified scheme of production in APL [7]

Finally, the Ministry of Environment is working in the elaboration of a new General Waste Law, which promotes the prevention of all waste production levels (industrial, domestic and institution waste, etc.)

The law will emphasize in a hierarchical strategy about the waste control in this order: reduction, re-use, and recycle (3R), then energy valorization, treatment and final disposal of them.

Research on construction waste

In the year 2005 an article in the Journal "*Revista de la Construcción*" [1], conducted a study of height construction building in relation to waste generation. It showed the common actions of some Chilean construction companies for the waste minimization.

The results of the survey to 124 construction companies showed that the main actions for waste minimization are: Conform to ISO quality management systems, internal environmental politics and objectives of companies, implement a waste management plan, APL project, other plans or actions, and just have no plan or action.

Moreover, the same study concluded that the facts that produce waste generation are design, handling materials and the project execution.

Residues were divided in four categories: improbable, infrequent, frequent, and recurrent materials. The most recurrent materials are wood, concrete and plaster. It is indicated that the average are twelve $7m^3$ trucks that retire waste monthly.

Lastly, the article gives recommendations for a waste management plan, indicating that supervision and design rates are feasible to intervene, and by this way, decrease the waste generation. It also recommends the consideration of the different stages of a project's lifecycle and also the training of responsible people.

International background

It is estimated that C&D waste in the EU reaches 180 million tons annually [3]. The main waste producers are Germany, UK, France, Spain and Netherlands. The latter have the best re-use and recycle percentage with 90% [12].

In Hong Kong, C&D waste reaches up to 6,408 tons annually. Within the waste are ferrous and nonferrous metals, paper, and wood materials that are 87.1% recycled and then are exported, which generates income to the city [15].

A closer example is the Mexico case, in the Federal District, where until the year 2007 there were between 3,000 and 4,000 C&D waste tons generated daily. [11].

Normative in developed countries

In C&D waste context, the European Legislation´s principles indicate the obligation of separating normal waste from dangerous waste, and that all waste must be classified. However, there are some regions that have ambitious objectives like Brussels's region and Switzerland.

In Brussels, the legislation has a recycle of C&D waste of 75% and 100% respectively (excluding excavation materials) [13].

In Switzerland, the waste separation and classification is an obligation. Moreover, the contracting has to present a waste construction management plan. On the other hand, the customer has the control obligation over the waste retirement, carrying a classification and quantification registry [13].

C&D waste studies

In a study titled as "*Gestion des Déchets de Chantier*" [13] there is a section dedicated to the "interesting parts, responsibilities, and action opportunities", constituting objective factors that allow to each construction project actor involved, to take action for a low waste production in projects. Although it is a broad chapter, it can be summarized with the main ideas on Table 1.

In an article published in the Journal of Automation in Construction [16], it is mentioned that there are four reasons why there are different processes for generating waste: Construction technology, administration method, materials, and workers. It emphasizes the idea that workers have a preponderant role on the decrease of

waste generation because they are the ones who handle the materials.

Finally, it has a prominent list that shows uses of recycled material to advertise the vision of the multiple types of recycling materials possible. The main ideas are mentioned on Table 2.

Actor involved	Opportunity or main idea
Legislator and authorities	Publication of ordinances and decrees on the management of waste.
The client	Power to choose company or designer to help minimize waste.
The designer	Design projects involving reduction in waste generation
The Architect/ Engineer	Knowledge, the practice and the monitoring of methods involving waste reduction at different stages of a project.
The contractor	Training and subsequent good performance around construction wastes.
The supplier	Avoid hazardous components in materials.

Table 1: Interesting parts, responsibilities, and action opportunities [13].

Recycled material	Use
Aggregates	Sub base, foundations, drainage, filling
Asphalt	Sub base, added to filler
Excavation	Filling
Metals	Manufacture of new metal
Glass	Replacement of sand, pipe bed, filling
Plastic	Plastic, plastic wood, horticulture
Rubber	Rubber tiles, use of slate on the roof
Polystyrene	Manufacture of lightweight concrete

Table 2: Use of recycled material [16]

MONITORING CONSTRUCTION IN RENCA

Project presentation

The construction monitoring was done in a social housing project called "Pedro de Oña", a social housing condo located in the commune of Renca, RM. It is being built in three stages with a total of 590 houses.

The average house has about 50m2, a living and dining room, three bedrooms, a kitchen, and a bathroom. It´s a two floor edification of confined masonry and concrete pillars and chains. The partition is built in wood and covered with gypsum-cardboard plates.

When the monitoring was done, the Project was in the second construction stage, with 227 houses, 2 head offices and 2 green areas. The average amount of workers in construction was about 60 people (Fig. 4).

Methodology

There were two weekly visits during a four month period. Each visit was filled with a standard form, with day house locations, construction procedure, involved materials information, and waste generated, all with pictures or videos (Fig. 5).

Figure 4: "Pedro de Oña" Project

Figure 5: Project construction

Results

The long amount of time monitoring allowed the complete construction process of some housing. Although it was not possible to reach an exact quantification of construction waste, it was possible to determinate some figures, which are displayed below.

There were about 500 to 600 pieces of brick being cut every day at the brick workshop. These were made to be placed alongside tensioners of the masonry wall. Moreover, for each masonry wall, 10 to 15 bricks were broken.

During the monitoring months, the waste average was 488 m^3 monthly (without aggregates). The above figure corresponds to an average of 31 outputs of waste truck (each truck with 16m^3 capacity).

Observations

Time spent at construction monitoring and the confection of forms allowed observation of the build mode and the behavior of workers. These can be subjective appreciations, but have value when they become repeated actions.

A poor handling of material was observed several times. For example, bricklayers sometimes had to sting a brick to insert it inside the wall in a perfect way; however, many times they hit the brick so hard, that it eventually broke the brick. At other times, it was observed a large volume of projected stucco on concrete surfaces. The consequence was a considerable amount of stucco quantity on the soil.

In the case of mortar paste for masonry wall, it was always observed that a large quantity of mortar on the stem walls' surface was falling as a result of the compression of bricks (about 15 lt of mortar in one masonry wall). The surface could be prepared to receive the fallen mortar, and its re-use could avoid send the material that was prepared, but that was not used, to the dump.

The absence of a periodic cleaning produced the accumulation of waste on the soil. It repeatedly observed new materials placed between wastes, which accordingly were collected in new materials as waste.

It is suggested that the main reason behind the waste generation, is its lack of waste management training for workers, derivative of a non-existent waste management politics in the company.

PROPOSED MANAGEMENT PLAN

From the observation and monitoring made in the construction project, and from the bibliographic review, a new proposal of waste construction management plan is presented. This plan conforms to the cycle of social housing construction project, considering its characteristics, and is focused on waste prevention from the beginning, considering different stages and involved factors (Fig. 6).

Proposal for each stage and participant

Mandator: Mandator can choose companies that promote waste reduction and also can force to prioritize materials that help minimize waste.

Designer: Must be trained and dominate the design of buildings that consider recyclable and reusable elements, also must impose waste management during the project.

Concerning the design there are some recommendations:

- Prioritize precast elements and always keep a unique design.
- Avoid the use of dangerous waste materials.
- Enumerate and describe elements with recycle and reuse possibilities.
- Accommodate the design of steel lengths, as far as possible, to standard sizes.
- Integrate trees and vegetation to the project place.

Besides, the designer must ensure the supervision of compliance of the waste management, directly or through a building inspector. Also, along with the construction company, he must be involved in the elaboration of an effective place for the waste management inside the work.

Tender: A special clause must be considered inside the tender, in the administrative database, which requires a waste management plan. Additional measures to encourage waste reduction can be included and indicate the estimated cost of moving waste to the landfill inside the general costs.

When the Project is awarded for a construction company, they will be responsible of the fulfillment of the waste management plan which is shown. The management plan in the construction stage is focused on prevention and reduction of C&D waste.

Prevention:

- Choose optimal materials for 3R management in work installation, perimeter fence, etc.
- Education and training of workers.
- Search buyers or deposits for recyclable and reusable elements.
- Organize an evacuation plan for waste.
- If necessary, organize the management and recovery of hazardous waste.
- Adequate transport of material inside the construction site.
- Good supervision of progress and correct planning to avoid constructive fails.
- Computer model of the future position of bricks on the masonry wall and cut only the exact number of necessary bricks.
- Keep the order of materials and tools in the construction site.
- Inspect materials upon arrival and return defective ones.
- Ask for suppliers that make retreat of their empty containers.

Reduction:

- Manage waste in the next order: reduction, reuse, recycle, composting, energy, valorization, and landfill.
- Separate containers for waste classification.
- Considerate that material that cannot be reusable in construction site can be reusable in another site.
- Have a responsible person to ensure waste management.

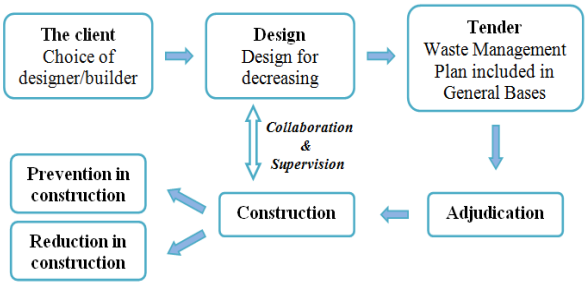

Figure 6: General management plan scheme

The application of these recommendations means considerable decreases in general costs because the minimization of waste evacuation. It also saves space on landfills, succeeding in the environmental impact reduction.

CONCLUSIONS

C&D wastes are a subject with little or no importance in social housing construction projects, which is not good considering that this type of project is the most important waste producer in the Chilean construction market.

The monitoring showed that there is a poor awareness about the importance of waste construction management. The workers did not show any care in material handling, which directly affected the waste generation. Moreover, the construction did not have any separate container for waste collection.

The management plan is focused in the prevention of waste generation, which means the reduction should be minimized and, accordingly, their costs too. However, it´s required the plan implementation from the beginning of the project, so incentives must exist that ensure the above.

Incentives can be economics or legislatives. Economic incentives could be the positive valorization of the company when it is observed as a green company. Another incentive is the important reduction in cost due to the reusable wastes, the selling of recyclable elements, and the reduction of waste evacuation to landfills. It is also recommended the elaboration of normative for waste construction, limiting the generation of these, and forcing the 3R management. The above must be done gradually, so that companies will be able to safely and effectively take the waste construction steps. For the proper functioning of incentives, training for workers on waste management is essential. They are the protagonists of waste management and from their care will be the production of less of the waste generation.

If a construction project implements this management plan, it would surely see reduction in their general costs due to the minimization of waste evacuation in reduction levels, which are above 80%.

Finally, if this management plan gets to be implemented on a larger scale, it could significantly decrease the waste construction production in Chile, creating new specialized jobs.

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