Methodology for the preparation of construction project waste management plans based on innovation and productive thinking processes: a case study in Chile.

Metodología para la preparación de planes de gestión de residuos en proyectos de construcción basada en procesos de innovación y pensamiento productivo: caso de estudio en Chile.

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Abstract
The construction industry generates the greatest quantity of solid waste in the world, which is now becoming an environmental and social problem for future generations. Efforts to decrease the impact of construction and demolition waste (C&DW) through mechanisms like clean production agreements, laws, decrees and legislation, among others, are not producing results. Therefore, this article describes a methodology to create a construction and demolition waste management plan (C&DWMP) based on processes of innovation and productive thinking. The plan, implemented in a construction project, aims to include strategies that not only classify and manage C&DW, but also avoid its production and disposal in landfills. The results show a high level of participation, involvement and open-mindedness from the project members. Their ability to come up with ideas and increase awareness to minimize waste was also an achievement. It should be noted that the effectiveness of the C&DW management plan is not presented from a quantitative point of view.

Keywords: Management plan; Construction and Demolition Waste; Innovation Processes; Productive Thinking; Case Study.

Resumen
La industria de la construcción genera la mayor cantidad de residuos sólidos en el mundo y se están convirtiendo en un problema ambiental y social para las futuras generaciones. A pesar de los esfuerzos hechos para disminuir los impactos de la generación de residuos de construcción y demolición (RC&D), a través de mecanismos como los Acuerdos de Producción Limpia, Leyes, Decretos, Resoluciones, entre otros, aún siguen siendo poco significativos en términos de resultados. Es por esto que en este artículo se describe una metodología para elaborar un Plan de Gestión de RC&D (PGRC&D), basado en procesos de innovación y pensamiento productivo, que busca incluir estrategias no solo para clasificar y manipular los RC&D sino para evitar que se produzcan y lleguen a los vertederos, y los resultados de su implementación durante la construcción de un proyecto de edificación. Algunos de los resultados muestran la alta participación, involucramiento, apertura mental y capacidad para proponer ideas por parte de los actores del proyecto, la generación de conciencia hacia la minimización de los residuos, entre otros. No se logra presentar la efectividad del PGRC&D desde el punto de vista cuantitativo.

Palabras clave: plan de gestión, residuos de construcción y demolición, procesos de innovación, pensamiento productivo, caso de estudio.

Introduction and Description of the Problem

The construction industry has an enormous and continuous impact on the environment (Yeang, 1999). Research carried out indicates that construction waste makes up 45% to 65% of waste dumped in landfills (Shi & Xie, 2009). In Chile, 37% of solid waste generated in metropolitan regions is from construction (Martínez, 2003).

The economic and environmental benefits of C&D waste management are enormous (Tam, Tam, Chan, & Ng, 2006). An affective C&DW management plan, whether it be at project or government level, could contribute significantly to reducing the amount of construction and demolition waste. It may result in a saving of up to 50% in waste handling costs, a 15% reduction in volume of the waste generated before recycling and a 43% reduction in the waste taken to landfills (Mcdonald & Smithers, 1998).

Most research has revealed that there are many environmental, social and economic benefits associated with a C&DW management plan (Tam, Shen, & Tam, 2007). These will lead to an improved public image, achieve greater construction productivity, save time and improve industrial security (Tam et al., 2007). However, C&DW management has so far not been successfully applied and further work must be carried out in order to achieve satisfactory standards (Tam, 2008).

C&DW management plans implemented in the construction phase have been proposed by authors such as (Mcdonald & Smithers, 1998), (McGrath, 2001), (Chen, Li, & Wong, 2002) and (Shen, Tam, Tam, & Drew, 2004). Furthermore, (Cha, Kim, & Han, 2009) have proposed using a tool to evaluate waste management prior to the construction phase. However, there are few methodologies that offer guidelines on how to create a C&DW management plan (Shen et al., 2004) that incorporates actions beyond the management of waste once it has been generated on the building site.

This article describes a methodology for creating C&DW management plans for any type of project. It incorporates a hierarchy to avoid, reduce, reuse and recycle waste that was proposed by (Deng, Liu, & Hao, 2008), (Shen et al., 2004) and (Kartam, Al-Mutairi, Al-Ghusain, & Al-Humoud, 2004). The results correspond to the implementation of this methodology in a construction project in Chile.

Literature review

The literature review concentrated on four areas: sources, causes and C&DW procedures; C&DW plans; innovation processes; and techniques and methodologies of creativity and productive thinking. The findings from each of the areas are described below.

Sources, causes and C&DW procedures

The management procedures were classified and connected to each of the sources and causes of C&DW generation. Each procedure fulfilled the requirement to avoid, reduce, reuse and recycle C&DW (See Annex A).

C&DW plans

(Mcdonald & Smithers, 1998) implemented a C&DW management plan which aimed to reduce, reuse and/or recycle C&DW. The main strategies used to achieve these objectives were: to prepare an inventory of materials that were likely to be discarded and evaluate their potential for reuse and recycling; to evaluate the costs of disposing the waste; and to develop a practical method to collect waste and employ recycled materials in temporary projects.

(McGrath, 2001) propose using Site Methodology software to audit, reduce and target waste (SMARTWaste). The aim is to identify waste generation sources and quantify the amount of waste produced. The principle of the system is to increase the recovery and reuse of materials and reduce waste generation in future sites by employing audited refuse as a point of reference of waste control (Shen et al., 2004) and (Aldana & Serpell, 2012).

(Chen et al., 2002) has come up with a scheme called the Incentive Reward Program (IRP) which is based on a bar code system. The program quantifies, in real time, the exchange of materials between the warehouse and the work crews to evaluate the level of use of the materials and reward workers according to how much they manage to save.

(Shen et al., 2004) propose the Waste Management Mapping Model (WMMM), which incorporates the good waste management practices employed in Hong Kong. The model proposes introducing a C&DW management plan prior to beginning construction activities, specifying the resources necessary for the management of waste and for mitigation of the waste generated through the timely identification of material that could be reused (Aldana & Serpell, 2012).

(Cha et al., 2009) suggest utilizing the Waste Management Performance Assessment Tool (WMPAT) application which was designed on Excel and uses Visual Basic. This application facilitates the analysis of a project's construction processes to give an indication of the performance of waste management and recommend procedures to make it easier.

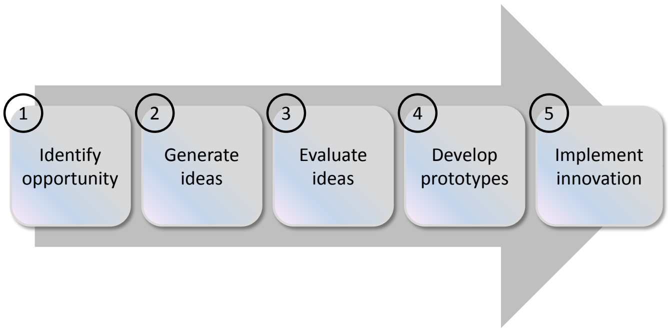
(Cheng & Ma, 2013) present a Building Information Modeling (BIM) system developed for the estimation and planning of demolition and renovation waste. The system can extract material and volume information through the BIM model and integrate the information for detailed waste estimation and planning. Information on materials can be extracted and provided to recyclers before demolition or renovation to make the recycling stage more cooperative and more efficient. Truck requirements and a waste disposal charging fee for different waste facilities can also be predicted through the system.

(Wu, Ann, Shen, & Liu, 2014) give an analysis on the methodologies used to quantify C&DW at a project and regional level. They conclude that it is not possible to define one method alone to quantify waste and propose employing a decision tree to select the most appropriate method according to the situation.

Innovation processes

A methodology was proposed to create new products, services, organizational methods and processes with clear steps and objectives that aimed to maximize creative impulse in order to generate innovative results. This methodology was created by a leading design and innovation consulting company in the United States, IDEO, that has established five steps to resolve a problem creatively (see Figure 1):

Figure 1. Innovation process used by the company IDEO. Source: Self-Elaboration from several sources, 2014.



(Reali, 2008) presents a number of flexible creative problem solving (CPS) models in which a different focus is used each time the solution to a problem is sought. Some of the CPS models are: (1) Applied Imagination, (2) Synectics, (3) Lateral Thinking Creativity Step by Step, (4) The Universal Traveler, (5) A Whack on the Side of the Head, (6) Creating, (7) What a Great Idea, (8) Simplex: a Flight to Creativity, (9) Creative Approaches to Problem Solving, and (10) Jump Start your Brain.

Techniques and methodologies for creativity and productive thinking

Techniques designed to stimulate creativity were investigated and the following ideas were found: (1) Brainstorming, (2) Substitute, Combine, Adapt, Magnify, Put to other uses, Eliminate, Rearrange (SCAMPER), (3) Random Stimulation, (4) Nominal Group Technique, (5) Analogies, (6) Masks, (7) Ideas Box, (8) Mental Maps, (9) Creative Collage and (10) The Desire Diamond.

Regarding productive thinking, the Galeforce methodology stands out. Personal productive thinking is based on a platform of skills on which innovative culture is constructed and encourages people to think beyond the traditional and the predictable (Hurson, 2010). This is the common denominator in the profile of professionals in the construction sector. The idea that creativity is a gift possessed only by certain individuals has been silenced by the large quantity of training programs throughout the world that aim to stimulate creative thinking skills (Fleith, Renzulli, & Westberg, 2002).

The theory of productive thinking was formulated for the first time by Erich Fromm. Fromm described thinking as considering a particular question and carefully using objectivity, along with respect for the problem as a whole. Thinking is a habit and most people struggle when trying to focus on productivity in their work. However, no matter the amount of cutting-edge technology and tools one uses, the right way to think and act must begin with one's self. Otherwise, it will not be possible to effectively apply these tools to become productive (Wertheimer & Wertheimer, 1991).

Methodology

Based on the literature review from the previous chapter, a methodology was designed to create C&DW management plans (see Figure 2). These plans are based on the innovation process used by IDEO, as well as on the Galeforce methodology and on developments proposed by the authors themselves through a combination of creative techniques and productive thinking.

Step 1: Identify an opportunity through the full understanding of a problem that needs to be addressed. In order to correctly define the opportunity, it is important to observe the problem and limit it. This will avoid digressions in the following stages of the proposed methodological process. In this stage the end result is the “creative focus”, which is the center of the innovation.

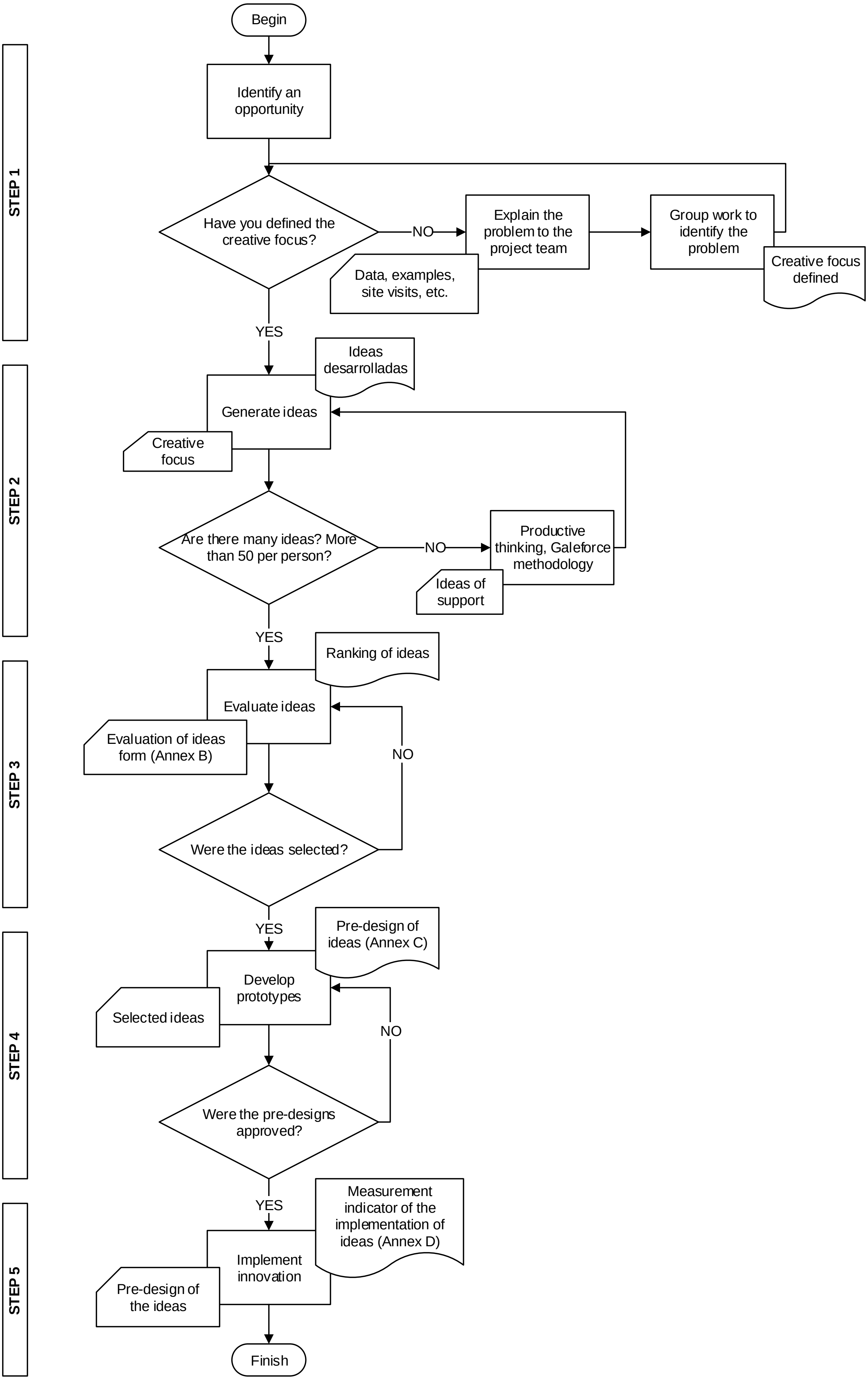
Step 2: Generate ideas. It has been said that the best way to have a god idea is by having many ideas (T Kelley, Littman, & Peters, n.d.) (Tom Kelley, 2007). Therefore, a dynamic is developed to generate ideas and to promote the discovery of new solutions for the creative focus based on established concepts. For example, a situation is created and a person is placed in the position of his boss. A round of questions from the “5 whys” technique is employed and the workers are involved to find out the root cause of the creative focus. Words are written on sheets of paper which are then deposited in a bag. Each of the participants takes out a word which is then written on a board. Next, each participant begins to construct sentences using the words put up on the board (these words do not necessarily have to have any topical connection to the creative focus). To help individual creative thinking, certain C&DW management procedures found in the literature (shown in Annex A) are taken as a starting point. Through creative techniques, this step significantly increases the probability that the ideas implemented turn out to be successful. Each of the participants generates a large quantity of ideas that go through three stages. In the first stage, people propose ideas that are not very creative. In the second stage, people are motivated to generate ideas that are more robust and creative than the first stage. Finally, in the third stage, better quality ideas than those from the first two stages are put forward.

Step 3: Evaluate ideas. In order to filter ideas, personal surveys are completed by the participants of the project. In these surveys, each person must grade the ideas they developed in the previous stage based on their effectiveness if implemented and the estimated cost of implementation. Subsequently, both factors are multiplied and the results of each participant are added together to obtain a final value for each idea and a ranking of ideas (see Annex B). This stage is carried out individually so that no one in the group is tempted by anyone else to alter their results.

Step 4: Develop prototypes. After the ideas have been evaluated in the previous step, they can be ranked in terms of their importance. Subsequently, groups are created which must come up with a pre-design of the idea selected from the ranking to present to the team so that it can be evaluated and improved. Groups may add ideas that were ***NOT*** selected in Step 3 (ideas of support) to develop a proposal of greater value than the initial one. Important details are recorded on a form so that they are available when the idea is being implemented on site (see Annex C).

Step 5: Implement the innovation. With the plan designed, discussed and approved, the next stage is to implement it on site. To achieve this, a measurement instrument has been developed to indicate the effectiveness of the C&DW management plan. An index is obtained for each week of the implementation process to help monitor the performance of the ideas when implemented on site. In this way, any digressions can be corrected or the idea can be discontinued if not successful in the short term (see Annex D). This evaluation should be carried out by going over the different areas of the project to evaluate the conditions under which the ideas are being implemented. The evaluation needs to be done at different times and on different days in the evaluated weeks so that the workers are not aware of the assessor’s routine and so do not behave in an unrepresentative way.

Figure 2. Flow diagram of methodology used to create C&DW management plans. Source: Self-Elaboration from several sources, 2014.



The methodology was applied to an educational construction project located in the center of the city of Santiago de Chile. The built area is 16,000 m^2 with 5 underground levels and 4 upper floors. Each upper floor is about 2,000 m^2. The project team consists of 12 people: six civil engineers, four builders, site managers, foremen, a program and budget manager and a quality control manager. The results of each of the stages of the methodology are as follows:

Step 1: The following question was defined as the "creative focus": How can C&DW be avoided, reduced, reused and/or recycled before it is taken to the landfill? This focus was chosen after a study carried out by the construction company found that it was producing a large quantity of C&DW which was having a significant impact on costs. Approximately 20% of materials bought for construction projects end up as waste, which increases direct costs by up to 50% (in some cases).

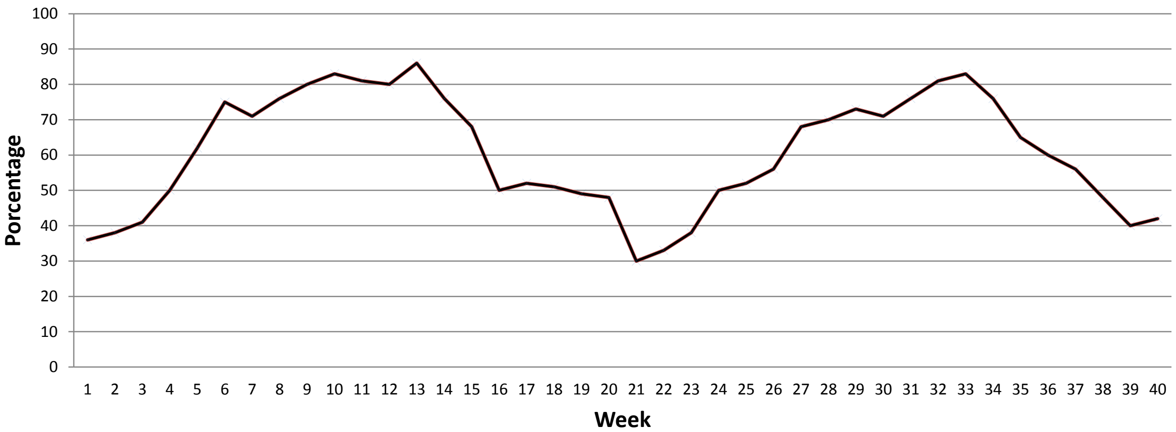
Step 2: Initially, some supporting ideas (Annex A) were given to the project team. However, due to there being few ideas, the Galeforce and other methodologies presented in previous chapters were applied. This required each participant to come up with 50 ideas, which gave a total of 600 proposals after only 20 minutes of work. Subsequently, each of the participants selected their 5 best ideas which were then grouped to give a final list of 28 ideas.

Step 3: The survey used to filter the ideas was sent to the 12 participants, of which 9 responded in the established time. From the results, the 11 best ideas in terms of cost and effectiveness were selected. The ideas chosen were: (1) 5 minutes of recycling, (2) modulation of materials, (3) fixed and mobile waste storage centers, (4) reuse of concrete through the use of pre-fabricated components on site, (5) modulation of formwork panels and wood according to their uses, (6) installation of material cutting centers, (7) replacement of certain materials through the recycling of other waste materials, (8) use of metal meshes in concrete joints, (9) provisional installations made with regulated materials of standard sizes that are easy to reuse, (10) incorporation of clauses in sub-contracts that facilitate the reduction of C&DW, and (11) new techniques for utilizing products that avoid waste.

Step 4: The results of the previous step were presented to the whole project team. To develop the prototypes, the team was divided into two groups and the 11 ideas were distributed between them. At the end of the session, each team presented their ideas using the form found in Annex C, and in no more than 5 minutes. Finally, 11 ideas were selected to implement in the project. Detailed logistics required for their implementation were defined for each idea.

Step 5: The people responsible for the implementation of the ideas were chosen in the pre-design stage and weekly checks were carried out. Monitoring was done to see if the idea was being executed as initially defined, if it required modification or if it needed to be discontinued due to failed implementation or a lack of feasibility. The evaluation of the effectiveness of the implementation was carried out using the form from Annex D. The final result of this evaluation showed that 61% of the ideas were able to be implemented over the course of the project. The index of the first 20 weeks corresponds to the structural work stage and the index of the subsequent weeks corresponds to the finishings (see Graph 1).

Graph 1: Performance index of the implementation of the C&DW management plan. Source: Self-Elaboration from several sources, 2014.



Discussion and Conclusions

One of the key aspects in the innovation process is working in a team with highly divergent (diversity of opinions and ideas) initial stages. Both convergent and divergent thinking are relevant and are developed repeatedly in the process because both are necessary in order to produce innovative solutions. Likewise, self-confidence, creativity, a sense of purpose, teamwork skills and the level of adhesion to the solution will grow in the participants. All of these characteristics, developed using a methodological solution for the generation of C&DW management plans, were seen in the project's participants.

During the implementation and execution of the ideas, 3 steps were observed that strongly stood out in the results. The first, called the Initial Step, is where the team starts to get to know the ideas in practice. Here the first difficulties arise and adjustments are made to achieve implementation. The percentage of implementation is low but improvements are visible in the project with respect to the initial situation without the C&DW management plan. Later, once the necessary adjustments have been made, the Maturity stage begins, in which a more fluid execution of the procedures by the construction professionals can be observed.

External support is necessary but not as rigorously and frequently as in the first stage. Next, after some time has passed and the project begins its most critical phase, the volume of production increases and setbacks occur. It is now when the third stage, Abandonment, can be clearly observed. The vast majority of ideas that have been implemented are left to one side due to pressures from the project. The management of waste ceases to be important and all effort is put into trying to finish the project on time.

Despite the abandonment of the C&DW management plan, the project team was available and willing to participate in the proposed methodology. Also, through training programs, awareness was raised among the workers. Although it was not measurable, in practice there was a noticeable change in the workers' behavior, such as when they came up with new ideas and reused materials.

In order to achieve the aims of a C&DW management plan, it is important to have a team leader to coordinate and watch over the project. Otherwise, although not as important as issues like the cost, deadline and quality, it may lead to lack of motivation and quick abandonment of the plan. This is perhaps especially true due to the fact that a C&DW management plan is a new activity in the project and is new to the workers.

The creation of a C&DW management plan introduces a new element to project planning. Clear guidelines must be produced that involve the key participants of the project to make it participative and social and raise awareness of the problems with C&DW. The plan also provides a tool to ensure its implementation via an indicator that helps the administration to monitor the project and subsequently make decisions.

It is recommended that for future phases a C&DW management plan should be designed which integrates the different areas of construction projects to measure its effectiveness and generate a culture of waste management that ensures the project never reaches the abandonment phase.

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Annex A. Sources and causes of C&DW generation and actions

Sources	Causes	Actions
Contractual (Osmani et al., 2007)	Error in contract documents *(*Bossink and Brouwers, 1996; Ekanayake and Ofori, 2000; *Osmani et al., 2007; Yahya and Boussabaine, 2006)*, *contract documents incomplete at the start of construction (*Bossink and Brouwers, 1996; Ekanayake and Ofori, 2000; *Osmani et al., 2007), error in the project records (Aguirre et al., 2005), selection of low quality products (*Ekanayake and Ofori, 2000), lack of contract incentives (Al-Hajj and Hamani, 2011).	
Designs (Bossink and Brouwers, 1996; Ekanayake and Ofori, 2000; Chung and Lo, 2003; Polat and Ballard, 2004; Osmani et al., 2007; Al-Hajj and Hamani, 2011)	*Changes in the designs (*Bossink and Brouwers, 1996; Ekanayake and Ofori, 2000; Polat and Ballar, 2004; Aguirre et al., 2005; *Yahya and Boussabaine, 2006;* Osmani et al., 2007; Jaillon et al., 2009), *designs and complex details (*Ekanayake and Ofori, 2000; Osmani et al., 2007)*, errors in designs and construction details, unclear or inadequate specifications, poor communication and coordination (Osmani et al., 2007); lack of information about the types and sizes of materials in the design documents, errors in the types and sizes of materials in the design documents, determination of types and dimensions of materials without considering waste (Polat and Ballard, 2004), lack of knowledge about construction during the design phases (*Ekanayake and Ofori, 2000; *Chandrakanthi et al., 2002 and Tam et al., 2006), lack of knowledge about the sizes available on the market, designers unfamiliar with alternative products, lack of information in the drawings (*Ekanayake and Ofori, 2000), poor designs (Kofoworola and Gheewala, 2009; Al-Hajj and Hamani, 2011), poor structural details (Kofoworola and Gheewala, 2009), inadequate designs (Al-Hajj and Hamani, 2011).	*Cooperative design, designs suitable for building, definition of the project, design of structural matrix, 3D models, cross-functional teams, exchanging incomplete information, (Polat and Ballard, 2004), designing for deconstruction, using standard dimensions and units, using prefabricated units, specifying recycled materials, using standard materials, avoiding making late variations in the designs (Osmani et al., 2007); promoting a suitable project acquisition system where experience of contractors on construction methods and sequences can help make decisions during the design stage (Ekanayake and Ofori, 2000), use of preformed materials that have been prefabricated off site, utilizing standard components, using real component sizes, capacities and specifications, minimizing temporary work, optimizing the design's shelf-life, allowing specifications of recycled materials in the designs, designing for recycling and easy dismantling (Keys et al., 2000).*
Purchases (Bossink and Brouwers, 1996; Ekanayake and Ofori, 2000; Chung and Lo, 2003; Polat and Ballard, 2004; Osmani et al., 2007; Al-Hajj and Hamani, 2011)	*Errors in the orders (Bossink and Brouwers, 1996; Ekanayake and Ofori, 2000; Yahya and Boussabaine, 2006; Osmani et al., 2007), difficulty in ordering small quantities (Ekanayake and Ofori, 2000; Osmani et al., 2007 and Tam et al., 2006 b), errors made by the providers (Osmani et al., 2007); over-ordering materials (Bossink and Brouwers, 1996; Ekanayake and Ofori, 2000; Polat and Ballard, 2004; Al-Hajj and Hamani, 2011), ordering smaller amounts of materials (Bossink and Brouwers, 1996; Ekanayake and Ofori, 2000; Polat and Ballard, 2004), provider errors (Bossink and Brouwers, 1996); ordering materials when the requirements have not been completely defined in the design documents (Polat and Ballard, 2004), specifications of unsuitable materials (Aguirre et al., 2005), product imperfections (*Ekanayake and Ofori, 2000; *Tam et al., 2006 b), bad quality products, purchase of unsuitable materials, bad advice from the providers (Al-Hajj and Hamani, 2011).*	*Structuring the work, training providers, association (Polat and Ballard, 2004), informing providers about the requirements of the construction process, requesting materials in good time, adopting requests on time, ensuring that requested materials arrive on site, ordering materials of the right sizes, ordering the correct quantities of materials (Poon et al., 2004; Al-Hajj and Hamani, 2011); efficient purchase of materials, efficient ordering of materials (Chen et al., 2002), deliveries on time (Al-Hajj and Hamani, 2011).*
Transport (Osmani et al., 2007)	*Damage during transport (*Ekanayake and Ofori, 2000; *Yahya and Boussabaine, 2006;* Osmani et al., 2007; Al-Hajj and Hamani, 2011)*, difficulties in delivering due to reduced accessibility of construction vehicles, insufficient protection during unloading, inefficient unloading methods (Osmani et al., 2007), provider negligence (Tam et al., 2006 b).*	
On site (Osmani et al., 2007)	*Inadequate on site transport, problems with unloading and/or storage due to bad material control (Aguirre et al., 2005), lack of waste management plans, incorrect planning of the required materials, delays in providing information about types and sizes of materials and components that are going to be used (*Ekanayake and Ofori, 2000; Osmani et al., 2007)*, lack of control of materials, lack of supervision (Osmani et al., 2007), supplying materials without packaging (Tam et al., 2006 b), using any material just because it's closer to the building site (*Ekanayake and Ofori, 2000), off-cuts of materials (*Yahya and Boussabaine, 2006;* Jaillon et al., 2009), lack of control on site (*Yahya and Boussabaine, 2006)*, dimensional deviations of concrete components like slabs, beams and pillars (Kofoworola and Gheewala, 2009), packaging of materials, damage caused by work methods (McGrath, 2001), lack of worker awareness, redoing work, unqualified labor, time pressure (Al-Hajj and Hamani, 2011).	*Carefully inspecting the merchandise when it arrives on site (Poon et al., 2004); using modern technology (Chen et al., 2002), educating contractors (Ekanayake and Ofori, 2000), appropriate storage of materials (Al-Hajj and Hamani, 2011).*
Storage of materials (Osmani et al., 2007)	*Inadequate storage space (*Ekanayake and Ofori, 2000; Osmani et al., 2007)*, unsuitable storage methods (*Ekanayake and Ofori, 2000; Osmani et al., 2007; Al-Hajj and Hamani, 2011)*, materials stored a long way from where they are used (Osmani et al., 2007), stores located in unsuitable places (McGrath, 2001).*	Providing materials with adequate protection, limiting the amount of material stacked up (Poon et al., 2004), efficient storage (Chen et al., 2002).
Handling materials (Bossink and Brouwers, 1996; Ekanayake and Ofori, 2000; Chung and Lo, 2003; Polat and Ballard, 2004; Osmani et al., 2007; Al-Hajj and Hamani, 2011)	*The supplying of loose materials, unsuitable storage methods both in stock piles and in the places the materials are used (Osmani et al., 2007), inappropriate handling, (Chen et al., 2002; Osmani et al., 2007; Al-Hajj and Hamani, 2011); damage during transport to the site, unsuitable storage (Bossink and Brouwers, 1996; Polat and Ballard, 2004; Al-Hajj and Hamani, 2011); bad handling of materials when not being used (Poon et al., 2004); inappropriate store locations (McGrath, 2001); unfavorable attitudes of the project team and workers and theft (Ekanayake and Ofori, 2000); poor management of materials (Kofoworola and Gheewala, 2009).*	Removal of packaging, 5S, on time deliveries (Polat and Ballard, 2004); using the right transport vehicles for the right materials, putting an end to the double handling of materials (Poon et al., 2004), handling the materials with sufficient care, careful control of the handling of materials (Chen et al., 2002), preventing the double handling of materials, ensuring adequate team management to avoid damaging materials, handling the materials mechanically (Al-Hajj and Hamani, 2011).
Operation on site (Bossink and Brouwers, 1996; Ekanayake and Ofori, 2000; Polat and Ballard, 2004; Osmani et al., 2007; Al-Hajj and Hamani, 2011)	*Accidents due to negligence (*Bossink and Brouwers, 1996; Ekanayake and Ofori, 2000; Aguirre et al., 2005; *Yahya and Boussabaine, 2006;* Osmani et al., 2007)*, unused materials and products, bad running of teams (*Bossink and Brouwers, 1996; Ekanayake and Ofori, 2000; Osmani et al., 2007)*, poor labor quality, incorrect use of materials, time pressure, poor work ethic (Osmani et al., 2007); human error (Bossink and Brouwers, 1996;* Ekanayake and Ofori, 2000; *Polat and Ballard, 2004), inclement weather, damage caused by subsequent activities (Bossink and Brouwers, 1996;* Ekanayake and Ofori, 2000; *Polat and Ballard, 2004), incorrect use of material that needs to be replaced (Bossink and Brouwers, 1996;* Ekanayake and Ofori, 2000*); bad work processes (Poon et al., 2004 and McGrath, 2001); attitude of the workers (Chen et al., 2002); imperfect construction plans (Polat and Ballard, 2004), errors in the sequence of construction processes, errors in the machinery and equipment used, tolerance of errors before repairing or demolishing (Aguirre et al., 2005), use of incorrect sizes (Tam et al., 2006 b), redoing work (McGrath, 2001).*	*Contracting of versatile workers (Polat and Ballard, 2004); designating central areas for cutting and storage of reusable parts of materials, locating the store in a convenient place for the operators but far from transport corridors, returning merchandise packaging to the providers (Poon et al., 2004), maximizing the reuse of materials, installing waste disposal containers, educating workers to reduce avoidable waste, rewarding workers for good practices (Chen et al., 2002; Al-Hajj and Hamani, 2011), recycling (Kofoworolo and Gheewala, 2009), using prefabricated components (Jaillon et al., 2009; Tam et al., 2006 b; Al-Hajj and Hamani, 2011), training of the project participants, registering and measuring the different waste flows, segregation of waste on site, reusing material off-cuts, recycling on and off site, appointing a waste administrator on site (Al-Hajj and Hamani, 2011).*
Waste (Bossink and Brouwers, 1996, Chung and Lo, 2003; Polat and Ballard, 2004; Osmani et al., 2007)	*Waste from the implementation processes, cutting of materials, uneconomical cuts, packaging (*Bossink and Brouwers, 1996 and Osmani et al., 2007)*, excessive cutting of materials (Al-Hajj and Hamani 2011); site cleaning (McGrath, 2001).*	
Others (Bossink and Brouwers, 1996; Polat and Ballard, 2004; Osmani et al., 2007)	*Weather (*Ekanayake and Ofori, 2000; *Osmani et al., 2007; Al-Hajj and Hamani, 2011), vandalism (Bossink and Brouwers, 1996 and Osmani et al., 2007), theft (Bossink and Brouwers, 1996; Ekanayake and Ofori, 200; Osmani et al., 2007), lack of control of on site materials, lack of waste management plans (Bossink and Brouwers, 1996; Chen et al., 2002; Polat and Ballard, 2004; Yahya and Boussabaine, 2006), lack of legislation and government policies, lack of recycling installations, lack of support from the company directors (Al-Hajj and Hamani, 2011).*	

ANNEX B. Form to evaluate ideas.

Evaluation of ideas					
No	**Ideas to minimize waste**	**Material**	**Effectiveness of the idea (E) (1 low – 5 high)**	**Cost of implementing the idea (10 low – 1 high)**	**TOTAL (EXC)**

ANNEX C. Form for the pre-design of an idea

Pre-design of the idea	
Name of the idea:	
Aim of the idea:	
Scope of the idea:	
Detailed description of the idea (include visual elements):	
Records to be used:	
Evaluation of the implementation of the idea:	
Persons responsible for the implementation of the idea:	

ANNEX D. Form to evaluate the implementation of the C&DW management plan.

Name of the evaluator: ____

Date of the evaluation: ____

Week of implementation #: ____

Final index: __________

Good: 80%-100%

Reasonable: 50%-79%

Bad: 0%-49%

Idea #	**Name of the idea**	**Control variables**	**¿Achieved?**		**Observations**
			Yes	**No**	
1					
2					