Packaging waste reduction in construction sites: eco-redesign of cardboard boxes

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Abstract

Packaging waste is a major contributor to construction waste, and cardboard is mainly generated during the electricity works. Of the environmental impacts caused by a product, 80% is defined during the design stage, including the impact of the packaging needed to deliver that product on site. This work proposes some strategies to reduce the packaging waste associated with two types of cardboard boxes for electric sockets, and evaluates the potential effects of these strategies. The comparison between the waste performance was based on an indicator defined by the Spanish Royal Decree for packaging and packaging waste, and the research performed on eco-redesign in other sectors was considered as the reference scenario to suggest some strategies to optimize the cardboard boxes. Although the results of the comparison do not show a big difference, together with the incorporation of some changes on the design they could help achieve some important savings for manufacturers, both environmental and economical.

Introduction

Throughout their life cycle stages, packaging systems consume natural resources and energy, generate waste and emit pollutants.[1] On the building industry, packaging waste is considered a major contributor to construction waste,[2] in particular, packages represent 50% of the volume of construction and demolition waste (CDW) in a construction work. Furthermore, in contrast to the increasingly widespread environmental policies, the products supplied to the construction work nowadays have suffered an increase in the volume of their packaging, to improve their level of protection and reduce their return percentage.[3] Llatas quantified a generation rate for packaging waste on 0.0819 m^3 per square meter of built surface.[4]

Waste packaging recycling and recovery are established under the Directive 94/62/EC of the European Parliament and the European Council on Packaging and Packaging Waste.[5] The main role of packaging is to deliver products to consumers in perfect condition, and according to the European Organization for Packaging and the Environment,[6] well designed packaging will meet this requirement with minimum environmental impact and cost, using only as much of the right kind of material as necessary, on the same line as the waste hierarchy[7] on the Waste Framework Directive (WFD) 2008/98/CE, where it is stated that the primary aim on waste management should be to minimize the total quantity of waste, in the case of CDW, the waste generated through a project. When considering packaging waste, the product stage is the appropriate moment to analyze if the packaging used is optimal to fulfill its protective function with the minimal amount of material, and this leads to eco-redesign.

Eco-design arises as a response to the need to introduce environmental criteria in the stages of production, distribution, use, recycling and final treatment of the product with the purpose of preventing or reducing the environmental impact throughout its life cycle. Eco-design is a product design strategy, and it requires the commitment of the manufacturer. The eco-design methodology incorporates environmental criteria into the design phase of a product. The environmental variable is considered as one requirement of the product, which is in addition to other conventions, such as cost, safety, utility, *etc*. The implementation of this variable should not affect the rest of the product properties.

The incorporation of environmental criteria for the prevention or reduction of the environmental impact of products can be approached in existing products or in the initial stages of a new product design. Thus, eco-design is a new product design considering environmental criteria, and eco-redesign concerns an existing product taking into account the same criteria. Eco-Redesign is an approach to *designing-out* as many environmental problems as possible, whilst still producing a high quality, cost effective product[8] and/or packaging. In Australia, the Sustainable Packaging Coalition (SPC) has developed an online tool, Comparative Packaging Assessment (COMPASS), based on life cycle analysis (LCA), to evaluate packaging design, helping professionals to incorporate sustainable criteria on their packaging design.[9] It is a web-based application for packaging designers and engineers, which compares the human and environmental impact of packaging.[10]

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Key words: Packaging waste; Eco-redesign; Best practices; Minimization.

Contributions: the work is developed based on one of the objectives of NGP's PhD, directed by MDM and OLC, who suggested to publish this specific part due to the originality of the application of introducing eco-redesign strategies for construction materials and their packaging. EMS was involved in the field study and during data collection, revised the results, and made the layout for the final version.

Acknowledgments: thanks to Luz y Ambiente, Madrid (Spain) for letting us samples for the data collection.

Received for publication: 4 October 2015.
Revision received: 25 May 2016.
Accepted for publication: 29 June 2016.

Waste Recycling Research 2017; 1:6
doi:10.4081/wwr.2017.6

At the national level, the Spanish Royal Decree 782/198 develops Law 11/1997 of Packaging and Packaging Waste,[11] and establishes the relation Kw/Kp as the main indicator to quantity the packaging reduction efforts. Kw is the total amount in weight of packaging waste generated during one year, and Kp the total amount of products packaged that same year.

This study focuses on cardboard boxes for electric sockets, previously identified, together with switches boxes, as the source of predominant cardboard waste in residential sites,[12] to quantify the impact of its eventual eco-redesign. Earlier Australian researchers approached the impact of plastic packaging by comparing the environmental performance of two plastic-based packaging systems.[13]

Materials and Methods

Previous results analyzing packaging waste generated in residential work sites showed that paper and cardboard waste is mainly generated during the building serv-

Table 1. Simon 31: packaging weight.

Simon 31 Content	Units	Observed weight (g) Empty box	Full box	Individual empty box	Individual full box
Frames box	20	182	616	8	52
Sockets box	10	156	1032	8	96
Functional unit	10	247	1340	-	-

ices phase, 70% of it corresponding to switches and sockets form the electricity sub-stage, generated towards the end of the construction works.[12]

The methodology to quantify the impact of eco-redesign of a cardboard box for switches or sockets is approached in three stages. First, an experimental comparison of boxes from two different suppliers to assess the waste performance is proposed, supported by the indicator Kw/Kp, Then other impacts are considered through the life cycle metrics of the COMPASS tool. These metrics were designed under a process guided by the SPC definition of sustainable packaging and ISO 14044.[10] Moreover, a research on other sectors, mainly food and beverage, is performed, to later select some best practices to propose as strategies for manufacturers to minimize the box weight.

Waste performance comparison

For the comparison of the waste performance the boxes of two brands were chosen as representative of the main source of cardboard packaging waste. The data of Simon 31 and Jung LS990 were collected through a field study, weighting both with and without their content.

The first one, Simon 31, uses recycled folding boxboard for its boxes; each socket is presented in a small individual box inside a bigger one containing 10 units (Figure 1). The frames are presented on the same way, by pairs, each box containing 20 units. For comparison purposes the functional unit of the boxes is defined as *cardboard packaging containing 10 units of electric sockets*.

The second sample, JungLS990, uses single wall corrugated cardboard, and does not present individual boxes, but a carton grid dividing the space in the box for the sockets, the frames come on another box (Figure 2). The data collection is performed by weighting the boxes with and without their content, obtaining the results summarized in Tables 1 and 2.

The main indicator to monitor quantitatively the degree of reduction for packaging and packaging waste is Kw/Kp, a dimensionless index based on the percentage rate between the packaging weight introduced on the market and the weight of the product it accompanies. Royal Decree 782/1998 includes Kw/Kp indicator to monitor the effectiveness of the policies for packaging waste prevention.[11] An example can be seen in the Environmental Declaration of the company Paver,[14] where they declared that for 2008 they commercialized a product: 2730 tons/year (Kp) and it had as packaging 60.9 tons/year (Kw), therefore the relation Kw/Kp is 0.0223.

Table 2. Jung LS90: packaging weight.

Jung LS90 Content	Units	Observed weight (g) Empty box	Full box
Frames box	10	38	234
Plastic fronts box	10	96	416
Socket box	10	98	612
Functional unit	10	232	1030

Table 3. Index Kw/Kp for analyzed packaging.

Model	Packaging weight (Kw)	Product weight (Kp)	Index Kw/Kp
Simon 31	247	1648	0,1498
Jung LS90	232	1262	0,1838

Figure 1. Simon 31 box with 20 frames and a small individual box.

Life cycle metrics comp0arison

To obtain the life cycle impacts with COMPASS the definition of a functional unit of comparison is established as *cardboard packaging containing 10 units of electric sockets*, and defined as follows:

Box 1: JungLS90 uses a corrugated box with 45% of post consumer recycled content, and weights 232 g, for 10 units.

Box 2: Simon 31 uses a recycled folding boxboard, and weights 247 g, for 10 units (Table 1).

The user inputs considered for this study are limited to material composition, and as the aim is to consider the possible eco-redesign, the only stage selected on the application is manufacture, excluding distribution and end of life.

Best practices research in other sectors

The Waste and Resources Action Programme published a case study named *Cardboard packaging optimization: best practices techniques*[15] where they confirmed that effective re-engineering of carton and corrugated cardboard packaging cuts costs and waste while retaining brand benefits and consumer appeal. Among their best practices the following can be highlighted what follows.

First, a biscuit company made significant packaging weight savings through relatively small changes to its biscuits cartons. The new pack had a thinner gauge of carton board, and the size of the glue flaps on the ends of the pack was reduced. Overall the changes produced an 11% reduction saving, without affecting the strength of the packs.

Second, a tomato puree brand found a total packaging solution, including merchandising and messaging on-pack to the consumer. The tubes were supplied in corrugated board shelf ready packaging placed directly on the supermarket shelves, with no cardboard box packaging. This change in format led to a net reduction of 1.8 tones of packaging in a full year.

Third, a packaging distributor investigated whether a change to a lighter weight single-wall corrugated cardboard carton could be achieved without sacrificing the strength of the original carton. After extensive strength tests, they came up with a range of new lighter-weight cartons branded the *Enviro-box*: the new cartons weighed less but were of similar strength to the current double wall cartons.[15] Ecoembes proposes various general practices of redesign aimed at manufacturers:[16] use containers of greater capacity; reduce the volume of the product to use fewer containers (concentrates, stacked, disassembled products); alleviation of the container by changes of design; optimization of palletizing mosaic; modification of the container design to facilitate a better use of the product.

Results and Discussion

With data from Tables 1 and 2 the index Kw/Kp is used to calculate the total amount of packaging waste for the analyzed models. Instead of considering the global amount of packaging weight introduced on the market and the packaging product, the index is adapted to the sample scale, using the ration between the mass of the packaging and the mass of the packaged product (Table 3).

The lower the ratio of the weight of the packing and the weight of the packaged product, less packaging has been employed for a same amount of product, therefore Simon 31 model has a more efficient packaging than Jung LS990. Table 3 results show that variation in the Kw/Kp index is not very significant, close to 10%. To consider other environmental metrics the following data of both types of boxes were introduced on the COMPASS application, Figure 3 shows the results of the metrics comparison.

Box 1 (Blue): JungLS90 uses a corrugated box with 45% of post consumer recycled content, and weights 232 grams. Box 2 (Red): Simon 31 uses a recycled folding boxboard, and weights 247 g. In Figure 3 SIMON 31 box is represented in red, and JUNG LS90 in blue. In many metrics JUNG LS90 has a smaller impact than SIMON 31, except in Green House Gas Emission and Acuatic Toxicity, due to the type of cardboard: the process to make the corrugated board consumes energy, and the coloring agents on a darker surface increase the toxicity released to aquatic environments. The rest of the metrics are favorable to JUNG LS90, basically because it is 15 g lighter than the other box. Finally, taking as a reference the strategies by WRAP described before, the following proposals can be presented to the manufacturers of both brands.

Simon 31: reduction of the area of the side flaps (Figure 4 left); redesign of the piece by removing the metal frame that excels in the profile (Figure 4 right) to reduce the total side of the box; replacement of individual small boxes by a carton grid to separate frames. Jung LS990: reduction of the weight of carton that makes up the boxes (Figure 5 left); reduction of the area of the side flaps (Figure 5 right).

The proposed improvements applied to switches and sockets could result in savings of around 8% of the area of the cardboard, reducing consequently the weight, and aside from contributing to reduce the cardboard waste in origin, they would especially be a double saving for the manufacturer, economic and environmental, by reducing the impact on the product stage.

Figure 2. Jung LS90 box with 10 sockets and another with 20 frames.

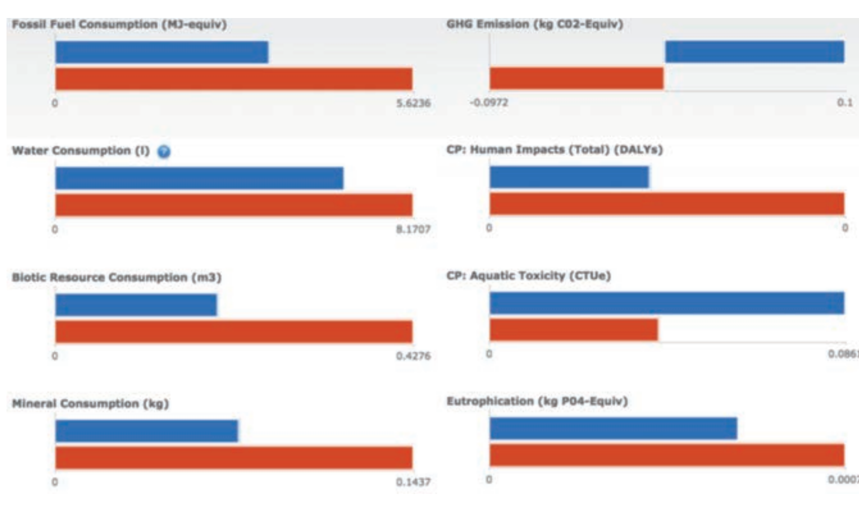

Figure 3. Life cycle metrics for Simon 31 (blue) and Jung LS90 (red).

Figure 4. Box with 20 frames in 10 boxes by pairs.

Figure 5. Empty box for sockets and another for 10 frames.

Conclusions

Packaging is in volume the biggest non-stony recyclable waste on a building site and it is defined during the product design stage. After comparing boxes from different brands the results manifest a certain margin that, attached to slight improvements in the design of both product and boxes, offers to the manufacturers savings in the cost of packing and the associated logistics. However, the life cycle metrics showed that the most performing packaging also implied higher environmental impacts in almost all the metrics. Therefore, manufacturers seeking for eco-redesign strategies must approach it as a complex purpose due to the amount of variables that need to be considered, besides the improvements associated with the mass reduction of the packaging itself.

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