

CONSTRUCCION AND DEMOLITION WASTE DURING THE TRANSFORMATION OF RURAL LAND

**¹Rivero Camacho, Cristina; ¹Marrero Meléndez, Madelyn; ¹Solís Guzmán, Jaime
Department of Building Construction II. School of Building Engineering.
University of Seville
41013
e-mail: *cririvcam@mail.com**

ABSTRACT

The main objective of this research is to create a new model for the quantification of construction and demolition waste generated during the transformation of rural land into urban state. The work starts with the quantification model developed in the research group ARDITEC, which uses coefficients for the calculation of the quantities and types of waste generated during construction works. The idea is based on the need to facilitate the urbanization waste management by town halls. In particular, it stems from the collaboration between the research group and Écija's town halls. Five real projects are studied, and the results are extrapolated to any urbanization work; and a tool is created for the accurate quantification, by means of simple calculations. Additionally, the coefficients obtained may be incorporated into Andalusia Construction Cost Database. The work will be part of future research of the environmental impact caused by the land transformations.

Keywords: CDW quantification, waste coefficients, natural resources, urbanization.

1.- Introduction and objectives

Urban progress consists of creating livable common spaces which are healthy and sustainable, in order to develop human life and the many interactions in which it is based. Achieving a well-planned city with proficient management of urban areas will ensure that the rest of the factors that conform it will be equally sustainable, developing synergistic effects between them and reducing possible impacts. The building environment in general and the construction industry in particular are the largest consumers of natural resources and energy. Furthermore, the building sector is the largest producer of waste, therefore the need to reduce these levels of waste becoming increasingly necessary.

To this end, governments with the help of associated organizations, seek ways to reduce the amount of waste produced, creating regulatory measures and control mechanisms. The RD 2/2008 Land Law [1] establishes the economic and environmental bases applicable to the ground throughout the entirety of the state territory. The aim is to achieve a sustainable building in which to conduct a shift towards the prevention of waste production, and an increase in recycling, reusing waste and use of renewable energies.

In the project, the current status of research on waste quantification is presented at an international level. A methodology is defined in order to develop a new model of quantification in construction work, and subsequently, a summary of the analysis of 5 real projects will be presented, with their respective conclusions.

In the model followed, all waste generating activities that are performed at this stage, among which are all necessary movement and land operations in preparation of the site, in order to make an efficient and responsible use of all those natural resources available in the ground which are likely to become waste. In addition, the configuration works of roads, steel and car parks will be taken into account, as well as the introduction and installation of urban services, such as a sewage system, supply and disposal of wastewater and stormwater, gas supply, street lighting, electricity supply, both low and high voltage, installation of telecommunication and gardening.

In order to compare the results, an assessment of these waste management works is deemed necessary, and a budget will be produced accordingly. This budget will take into consideration the possible negative prices, which will be when the waste to be treated is valued by an external company and entails benefits.

The project arises from the need to alleviate an existing deficiency in the management and control of waste generated in urbanization projects at administrative level. At the request of City Hall Ecija, specifically for Commonwealth which collaborates with our department in the investigation management RCDs. The aim is to create a tool that will be employed to estimate the amount of waste generated by the works of urbanization, with which to manage Taxes and avoid uncontrolled dumping of waste in unauthorized dumping sites. It is necessary to create scales for the development of the tool which will calculate the waste production of urbanization works according to its characteristics, namely surface type or facilities included within it. With the creation of coefficients we seek to provide the technician with the previous accounts of waste generation and cost management.

This project continues with the line of research of the department of Architectural Technology II, of the School of Engineering Building of the University of Seville. Previous research has managed to develop tools for the control of RCD in residential buildings. Currently they seek to continue the transformation of soils, making this project indispensable, and a crucial part of a group of projects that seek to continue and advance in this research. Furthermore, it will contribute to current studies regarding the calculation of the ecological footprint of urban transformation.

2.-Methodology

For the development of the methodology we should make several aspects clear in order to ensure optimal settings. To begin with, we must carry out the quantification of waste to be generated, depending on the items of work in which they are generated. After identifying all work, the estimated coefficients must be applied, which serve to calculate the total waste generated in each project, obtaining the type and quantity of waste per unit of work. Once calculated these quantities of waste, we proceed to testing and consider its possible recycling or reuse to finally establish the costs for the entire waste treatment process. 'Model Detailed budgeting' is employed. Since our study consists on tailoring rural land to urban land, no specific variables are detected, but a series of actions which in most cases will be the same in different projects, such as the implantation of the different and necessary installations in all types of land to ensure its consideration as urban land. By contrast, as the variation including total area difference is observed according to the project.

Process to follow:

- Compilation of regulations and documentation affecting construction waste both at a national and international level.
- Gathering urbanization projects for their study.
- Definition of a mathematical model to estimate the production of construction and demolition waste.
- Adaptation measurement criteria unification of all the items found and applying systematic classification.
- Obtaining of volumes of each type of waste separately. Waste identification and creation of coefficients.
- Summary of quantities, waste separation and coding LER.
- Creation of new parameters required for the internal configuration to future informatics calculation tool.
- Analysis of results and evaluation of differences and similarities.

3.- Cases studies

3.1.-Compilation of urbanization projects for study.

Thanks to the collaboration of the Ecija region with our research department (ARDITEC), and Talio Engineers engineering study, we have analyzed 5 projects of land transformation in this research. All of them have been completed, or are in progress, in recent years in the province of Sevilla.

The projects can be classified into:

- Industrial 1 and 2, with a Budget Execution Material (BEM) of 17,823,408.83 € and 826,791.37€ respectively.
- Residential 1, 2 and 3, with a Budget Execution Material (BEM) 917.427.64 €, 280,449.62€ and 1,235,143.46€ respectively.

Subsequently, and after the analysis of the results, the projects will be classified as small, medium or large in terms of the surface they cover.

3.2.-Definition of a mathematical model to estimate the production of construction and demolition waste.

In this project a method will be introduced in order to quantify different types of waste that arise in the construction site. For its development a table will be used in which all generators of waste items are included, classified and coded according to the Systematic Classification [2] as well as the total quantities of each item. In addition, for each item we will include every type of waste expected to be generated, to ensure that we have identified all waste according to each chapter, subchapter and items.

In the process of construction, three sources of waste are identified: demolition, debris and wastepackaging. These sources of waste also differ in the work in progress of urbanization. Demolition waste is a result of the process of demolishing buildings, existing facilities. The volume of debris refers to losses, offcuts and fracture of materials during the completion of the work, including the soil of the excavation. Finally, waste packaging includes packaging materials, cans, containers, pallets, etc.

Units and measurement criteria were taken from the geometrical characteristics of the components that make up the item. The system unit is the one traditionally employed, and all data is represented in the relative values that measure the amount of each item in m, m², m³, kg or per square meter built unit.

3.3.-Adaptation metrics unification of all items found and application of systematic classification.

As we know, project measurements consist of a list of items in which are the measurements of each unit of work are developed. In order to unify criteria when coding, the Systematic Classification [2] based on the Bank of Construction Costs of Andalusia, BCCA [3] has been put into place. In this project we have unified approximately 260 items, 65% are new codes created following the structure of BCCA all these, are proposed for future addition to the bank. We have also calculated over 200 new coefficients of waste generation.

3.4.-Volumes obtaining each type of waste separately. Waste identification and creation of coefficients.

Once the residues to be generated have been identified, the measurement of the quantities of each type of waste is performed. To do this we will use the transfers of those waste generating items, which have been identified and coded above. For the measurement we will need to create a series of coefficients to match the units and measurement criteria between source items and items for waste measurement. These coefficients are based on the following mathematical formulation (ec.1) for calculating the quantities:

$$Q_r = Q_i (CR * CC * CT) \quad (1)$$

Where:

Q_r = amount of waste

Q_i = amount of the work unit that generates waste

CR = coefficient to measure the origin of the constructive element becomes waste.

CC = coefficient for converting the unit of measurement from heading origin in the source drive of heading destination.

CT = coefficient for transforming the measurement criterion from heading origin on the criterion for measuring of heading destination.

The development of the coefficients mentioned above, will complement those already used in the "Selective Waste Removal: Budgeting Models" [4]. This study seeks to have a list of coefficients as extensive as possible, so as to have a quantification method that can take urbanization projects into account.

In order to do this this we identify two stages in the construction works to be performed, which will be the stage of previous work and earthmoving and the stage of urbanization, in which all those works of adaptation and implementation of installations are included. In this work, urbanization projects studied are of a sufficient size to include the largest possible number of items, with the aim of having a tool that combines a relation of items that may be extrapolated to most urbanization projects.

The following table (Table 3.4) shows the model employed for the transfer of items. The measurement of the amounts of waste will be classified according to established coding by BCCA, relating it to the LER coding we use to measure the total quantities. These transfers ensure the achievement of the unification of two types of classification, which facilitates quantification of the residues and allows for links to be established between the two types of coding. For quantification of waste generated in each of them, the values previously established for CR, CC and CT coefficients are applied.

MEASUREMENT									
IDENTIFICATION			DIMENSIONS				RESULTS		
Code LER	Code BCCA	Concept	Qi	CR	CC	CT	Assistant	Partial	Total
17		CONSTRUCTION WASTE AND DEMOLITION (INCLUDING EXCAVATED SOIL AREAS CONT.)							
17 01	17H	Concrete, bricks, tiles and ceramics							
17 01 01	17HHH00100	Concrete (m3)							
		09ISS00110	4320	0,1	0,041	1,25	22,14		
		15AAA00015	552	0,1	0,68	1,1	41,29		
		15AAA00015	552	0,05	0,685	1,1	20,8		
		15ACH00055	496	0,1	0,5	1,1	27,28		
		15ACH00260	1190	0,1	0,79	1,1	103,4		
		15ACP00006	7788,02	0,05	0,007	1,1	2,998		
		15ACP00007	490	0,05	0,008	1,1	0,216		
		15ACP00008	1352,14	0,05	0,009	1,1	0,669		
		15ACP00009	381	0,05	0,01	1,1	0,21		

Table 3.4 "Measurement of quantities of waste ranked by LER. Example ".

3.5.- Summary of quantities, waste separation and coding LER.

Once the measurement of all residues identified has been completed, a summary (Table 3.5) will be produced, with estimates of the total amounts of each residue, both in tons and cubic meters, according to Royal Decree 105/08 [5].

This will require the use of the densities of these materials that can be found in the CTE-DB-SE / AE (Equity Building) Annex C [6]. After the identification of those items of waste generation and its subsequent quantification by engaging the detailed model, with the calculation of coefficients and the classification based on the BCCA [3] and according to LER through order MAN / 304/2002 [7].

CODE	CONCEPT	VOLUME (m ³)	WEIGHT (T)
17	WASTE OF CONSTRUCTION AND DEMOLITION (INCLUDING EXCAVATED SOIL FROM CONTAMINATED SITES)		
17 01	Concrete, bricks, tiles and ceramics		
17 01 01	Concrete	4114,68	9875,232
17 01 02	Bricks	97,736	131,95
17 02	Wood , glass and plastic		
17 02 01	Wood	0	0
17 02 02	Plastic	20,559	28,782
17 03	Bituminous mixtures, coaltar and tarred products		
17 03 01	Bituminous mixtures containing coaltar	573,88	631,27
17 04	Metales (incluidas sus aleaciones)		
17 04 01	Copper	0,097	0,864
17 04 02	Aluminium	1,27	3,43
17 04 03	Steel	0,123	0,96
17 05	Soil (including excavated soil from contaminated sites), stones and dredgings spoil		
17 05 04	Earths and stone containing no hazardous substances	488405,21	830288,85
17 06	Insulation materials and construction materials containing asbestos.		
17 06 04	Insulation materials other than those mentioned in 17 06 01 and June 17, 03	1,08	0,162
15	WASTE PACKAGING; Absorbents , wiping cloths ; FILTER MATERIALS AND PROTECTIVE CLOTHING NOT OTHERWISE SPECIFIED		
15 01	Wood , paper, cardboard , plastics, synthetic and glass		
15 01 01	Containers of paper and paperboard	1,114	1,225
15 01 02	Plastic packaging	1,83	2,558
15 01 03	Wooden containers	2,104	8,427
15 01 10	Packaging containing residues of hazardous substances. Plastic and metal	4,15	5,8057363
TOTAL		493223,83	840979,511

Table 3.5, "Summary Table of Quantities, typology tym³. C.17 Industrial 1".

3.6.- Budget

In this section, the work of separation, reuse, evaluation and disposal of waste are assessed using the amounts calculated by transfers earlier in the quantification stage. We will use the model proposed in the Selective Waste Removal model: Budgeting [4] manual.

To estimate the total cost that a proper management of waste would entail, we will use the prices included in the latest update of the Base Construction Costs of Andalusia. In order to do this we will use the amounts calculated by implementing detailed model; amounts which have been summarized according to type of waste and measurement units in t m³.

The following is a representation of part of the budget corresponding to the project of urbanization "Industrial 1" (Table 3.6), as a reference to the budgeting model employed in the calculation of management costs of the RCD.

BUDGET DETAIL					
IDENTIFICATION		DIMENSIONS		AMOUNT	
CODE	CONCEPT	MEASUREMENT	PRICE	PARTIAL	TOTAL
17T. LAND					
17TTT00110	m ³ LANDS WITHDRAWN INERTES N. P. A LANDFILL AUTHORIZED 10 km Withdrawal of inertland in new works to landfill approved situated at a distance of 10 km, comprising: selecting, loading, transport, unloading and discharge fee. Measured foaming volume.	488405,206	7,46	3643502,837	
SUBCHAPTER 17H TOTAL: LAND.....				3643502,837	
17W. VARIOS					
17WWW00100	t WITHDRAWAL IN CONTAINER 3 m3 HAZARDOUS WASTE Withdrawal container 3 m3 of contaminated with hazardous substances on site to recovery plants situated at a maximum distance of 15 km, consisting of packaging : inland transport , freight , ground transport , unloading and management fee . Measured the weight placed on plants scale.	5,81	41,54	241,37	
SUBCHAPTER TOTAL 17H: VARIOUS.....				241,37	
BUDGET TOTAL WASTE MANAGEMENT				3.745.691,124 €	

Table 3.6 "Budget waste classified LER_ Industrial 1 (Part 3)".

4.- Results obtained.

With the aim of facilitating the task and to allow for quick and simple estimates to be carried out, scales of waste generation will be created. These shall be based on the type and the surface that is to be transformed, as well as certain peculiarities of the project in order to refine the results. They will be calculated for an area of a 1000m² plot, to obtain values of an acceptable proportion for further study and comparison. This will help the government and city hall, and even promoters, to generate a previous idea in relation to the rates costs regarding the management of waste from a particular construction work.

As our main observation, we can highlight the results obtained in the Industrial 1 and Residential 2 projects. Both differ significantly in terms of RCD volume, price or cost. We must not forget to emphasize the important role that the land itself plays in waste management. One can see that it is the main waste generated in the works of urbanization which makes very obvious the way to reduce the costs of managing them through the reuse of land. In the comparative tables that have been generated, we can observe the large reductions we accomplish through different percentages of land reuse.

4.1.- Surface per project.

The following graph (Fig. 4.1) depicts the m² corresponding to each project, in order to be able to compare, in a visual fashion, the sizes of each of them.

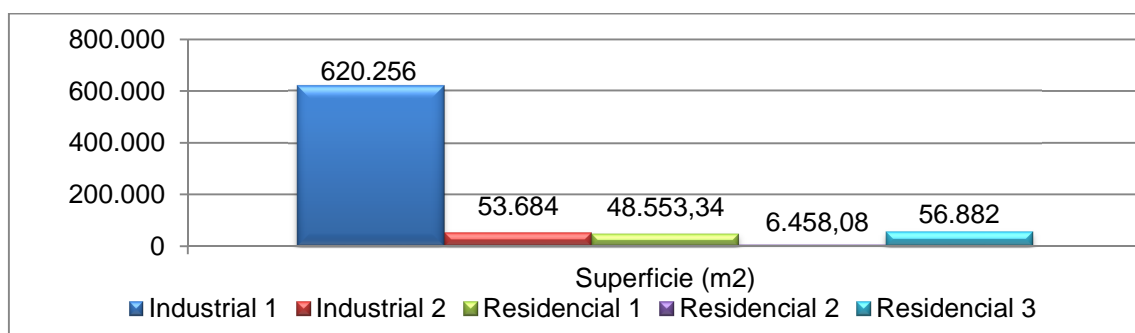


Figure 4.1 "Comparative area between projects, measured in m²"

Regarding these observations, we can state that we must differentiate between three urbanization projects based on their size:

- Urbanization projects whose area is less than or equal to 20,000 m²
- Urbanization projects whose surface is between 20,000 to 80,000 m².
- Urbanization projects whose surface is greater or equal to 80,000 m².

This will be a fundamental parameter in the computing quantification tool that will be created in a future research project carried out by our department.

When entering data of any project into this tool, it will be initially classified according to its surface. Subsequently, the introduction of the rest of the information is to be completed, in order to refine the estimating process of waste generation in any project, as well as its management costs.

4.2.- Costs for surface waste management.

Below is a representation of the (Fig. 4.2) expenses pertaining to waste management of each project, referenced to the surface thereof. From the results, we can draw several observations.

On one hand, the Industrial 1 has the largest area of all the projects. This causes a considerable increase in the amount of waste obtained in the category of land. We must not forget that this type of residue in particular represents 90% of the total waste. Therefore its management costs rise dramatically, as does every measure calculated for this project. On the other hand, the Residential 2, being the smallest of all in terms of surface, is in fact the largest in matter of project management m² costs due to the increased costs in repercussions. Like any urbanization project, it contains all the basic facilities for human consumption, as well as and paving, etc. These costs encompass a smaller surface where to distribute, the lesser the size of the project.

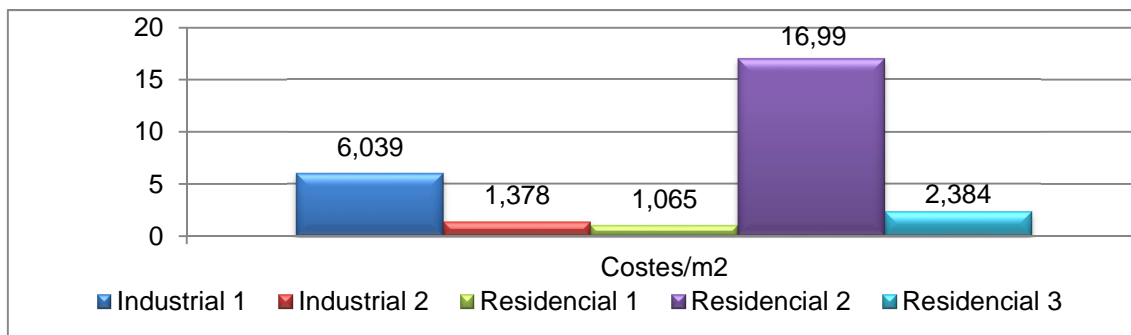


Figure 4.2 "comparative costs between projects, measured in € / m²"

4.3.- Comparison of waste generated in each project. Classification vats.

As a general comparative, (Fig. 4.3) is a representation of the volumes classified by materials and corresponding to each project, measured in m³ per 1000 m² of the corresponding plot. All materials except the soil are represented to avoid distorting the graphics. Results are expressed in logarithms to base 10, as well as are disaggregated in the adjoining table to facilitate its graphic understanding.

We can note that the material that is most abundant in the residues, after soil, is concrete, followed by bricks. These are the materials to be studied in detail during the waste management research of this type of project.

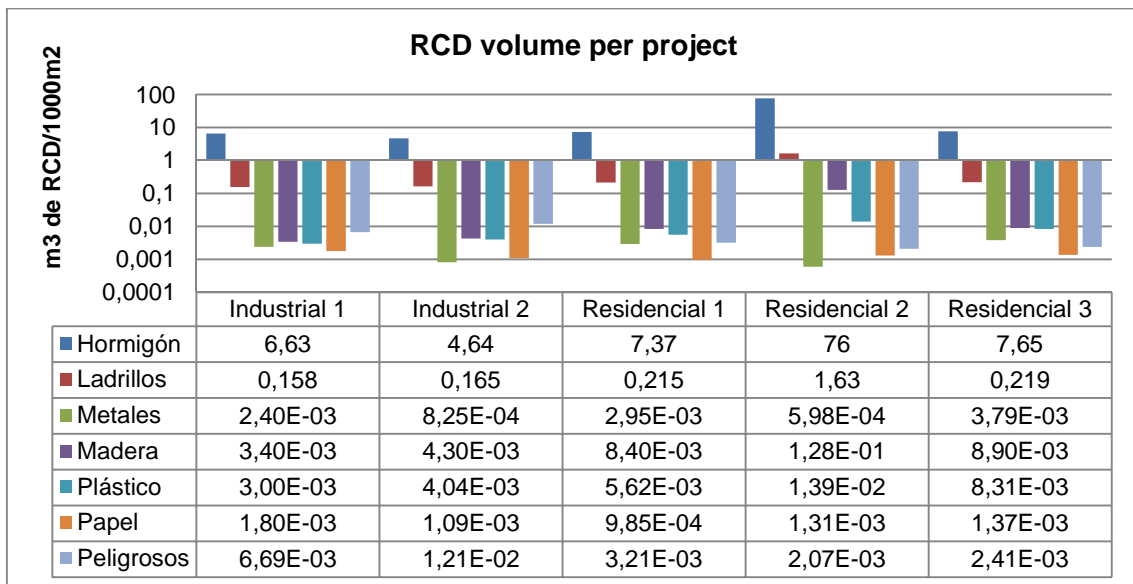


Figure 4.3 "RCD volume comparison between projects, measured in $m^3 / 1000m^2$ plot"

4.4.- Comparison of land generated in each project.

In the graph below, we can see the volume of land corresponding to each project (Fig. 4.4.1). The waste land is divided into extracted land and loss of land. They are measured in m^3 per 1000 m^2 of the corresponding plot. They are represented individually, as they account for approximately 97% of the total project RCD (Fig. 4.4.2).

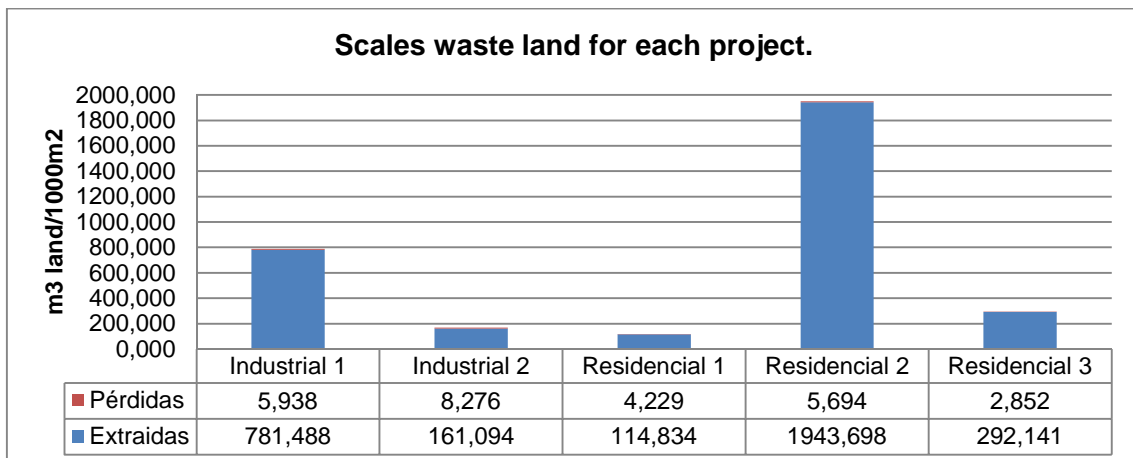


Figure 4.4.1 "Volume RCD land, comparison between projects, measured in $m^3 / 1000m^2$ plot"

The percentage representing land in the total volume of waste should be highlighted. This makes having a good study essential for the reuse of the land, as this will result in huge savings in management costs RCD and a decrease in the use of natural resources and a reduction of the environmental impact caused by urbanization projects.

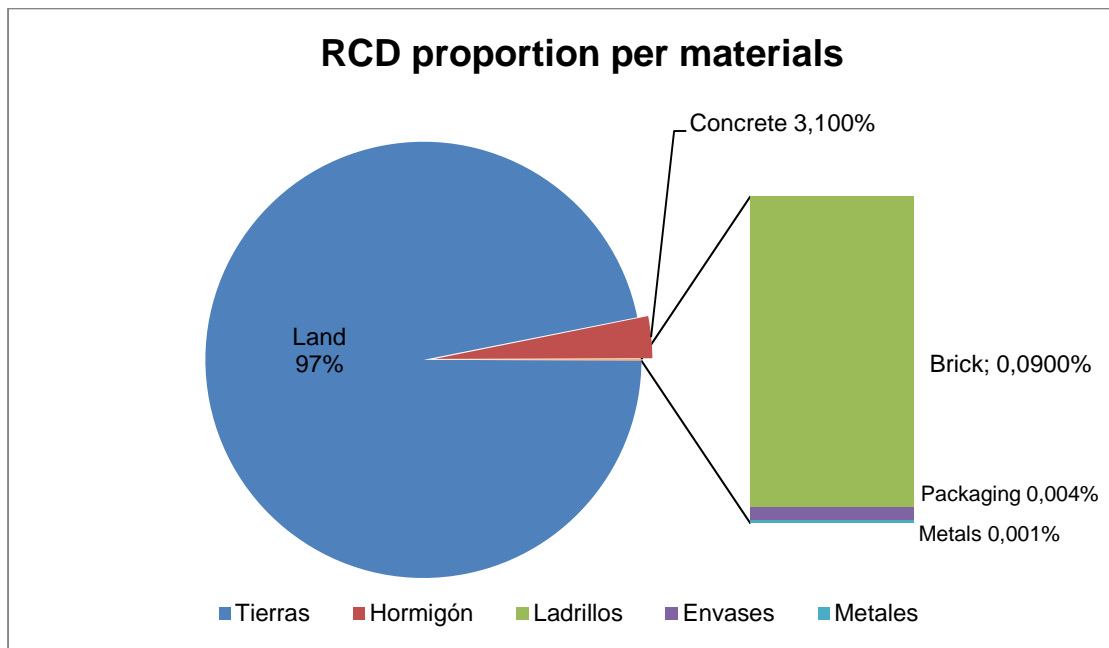


Figure 4.4.2 "Average proportion of waste generated in projects."

4.5.- Percentage of reused land.

As we mentioned previously, the high percentage that land accounts for in the totality of the generated waste in the works of urbanization makes them a good solution to optimize the costs of managing them (fig. 4.5).

With the tool developed to calculate variations of RCD volumes in land, and its costs, we have obtained the individual percentages for each project. In the following table, an average of these percentages was produced, to be applied to any project. It will also be an option to select the tool to be developed in future projects.

Through the means of this bar graph, we can see that the budget reduction is always proportional, regardless of the project area. This is because the main item in the budget for waste management research, relates to land (about 90%, as we saw in the previous sections).

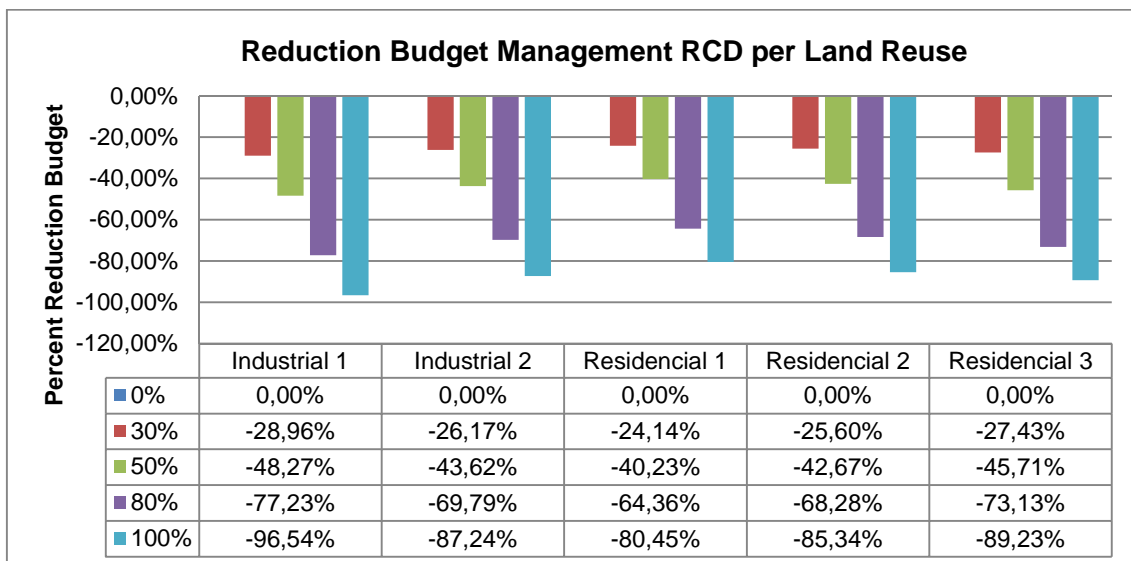


Figure 4.5 "Budget reduction percentages"

5.- Conclusions

- Activities of tree removal, clearings and earthmoving are the ones that result in the most waste production. We have seen in the projects analyzed that they

represent approximately 90% of the total RCD volume from urbanizations, industrial or residential.

- The correct management of waste corresponding to land, can entail significant savings to the promoter of the urbanization project. Applying the percentages of land reuse analyzed in each project, we have seen how we can reduce around 85% of the budget for waste management. In this way, we also ensure a reduction of the environmental impact.
- The new tool designed to compare the changes in the volume of waste by the percentage of reuse of land as well as the budget will be very useful not only to continue the study of urbanization waste, but will also be useful for other urbanization projects at their planning stage. It is able to easily optimize resources and find significant savings in the budget.
- The surface is an element of paramount importance in the classification of urbanization projects. We have discovered that according to the surface of the projects, we are able to begin discerning three types of urbanization projects. This is very evident in the percentages of RCD per installation and m², since in small areas it increases significantly. This is because the basic facilities for human consumption are always present in the projects and their impact on the land will be greater the smaller the surface.
- The results obtained may not be tested or compared with other case studies, since it is the first time that full impacts from urban development projects are analyzed without constructions. It will be the start of an investigation that will have as an aim to refine the data obtained and test it in real cases, as well as verify that the errors are within the limits established.
- This tool is intended to be implemented during the development of the transformation coefficients applied to BCCA. In this way, it would result in a model adapted to the BCCA and would allow for the simplification of quantification, and the unification of criteria for model development quantification for any urbanization project. Furthermore, the application of these coefficients is intended to develop a model that takes into account the environmental impact.

ACKNOWLEDGEMENTS

I want to thank to town hall of Ecija, for their collaboration with our department and the University of Sevilla, by providing information for the research carried out. Talio Engineering Study from Ecija, for providing me selflessly with the documentation for the study of development projects. Without them this project would not have been possible. This research is being conducted within the HERVEVA project, funded by the Agency for Public Works of the Junta de Andalucía (AOPJA) and European Regional Development Fund (FEDER).

REFERENCES

- [1] Ministry of Housing. 2008 Royal Decree 2/2008 of 20 June, approving the revised text of the Land Act is passed. BOE 154 of 26 June 2008.
- [2] Ramirez de Arellano, A. et al, 2010: Systematic Classification Basic Price, Auxiliaries and Unitarians.
- [3] Department of Housing and Planning of the Junta de Andalucía, 2010. Base Construction Costs of Andalusia 2010. Ministry of Housing and Spatial Planning of the Government of Andalusia, Sevilla, Spain.

[4] Ramirez de Arellano, Antonio; Llatas Oliver, Carmen and others (2002): Selective Waste Removal: Budgeting Model, Cultural Foundation of the College of Technical Architects of Seville, Sevilla.

[5] Ministry of the Presidency, 2008. Royal Decree 105/2008 of February 1, on the production and management of construction and demolition waste is regulated. BOE 13/02/2008.

[6] Ministry Of Housing. 2006 Royal Decree 314/2006 of 17 March, approving the Technical Building Code is approved. Recast with: modifications of RD 1371/2007 of 19 October and Error Correction BOE of 25 January 2008. Revision Effective from September 13, 2013.

[7] Ministry of Environment. 2002. Order MAM / 304/2002, of February 8, Laying Operations Recovery and Disposal of Waste and the European Waste is a publican.