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Optimization Methodology for the Use of Plasterboard and Steel Profiles in a Housing Project

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Abstract: At present, the construction industry generates the most waste in the world, accounting for about 35% of solid waste, and Chile has a similar proportion. For every square meter of construction, 0.26 m^3 of waste are generated, approximately during the construction phase. This study analyzed the San Andrés del Valle expansion building project of Aitue, a construction company located in Concepcion, Bio Region, Chile. We are seeking to develop a proposal to minimize material loss, particularly for the two most commonly used elements in building construction, such as cardboard plasterboard sheets and Metalcon profiles. In this way, the above materials can be optimized to reduce waste and achieve cleaner work. In addition, an economic analysis was conducted on the savings generated by on-site optimization of the studied materials.

Key words: optimization; construction waste; plasterboard; Metalcon galvanized steel profiles

1. Introduction

The construction sector is one of the most conservative sectors when it comes to innovation, maintaining the same construction processes for years (Pape and Nazer, 2021), despite the fact that these processes often generate excessive expenditure of materials and construction waste generation, which can exceed 35% of solid waste both globally and nationally (Aleksanin, 2019; Ghaffar et al., 2020; MINVU, 2018; Véliz et al., 2022).

It is predicted that 1500,000 new homes will be built in Chile by the year 2030. This is a result of the increase in population. This will produce an increase in waste in the country, increasing by 373% the waste that is currently being generated, causing an irreversible environmental impact. Chile generates about 0.26 m^3/m^2 of construction and demolition waste compared, for example, with 0.15 m^3/m^2 in Europe (Véliz et al., 2022). In addition, this has economic repercussions for construction companies, since the waste entails an economic cost for storage, landfill and transportation. Waste has been evaluated at 9.46 US$/$m^3$ (Bravo et al., 2019). Therefore, the generation of more waste increases the cost of these items. Therefore, it is essential to create new proposals to reverse and minimize both economic and environmental impacts as much as possible, benefiting the environment and the usefulness of each project (MINVU, 2018).

This study specifically analyzes Metalcon materials and plasterboards to optimize their construction processes, given the amount of losses generated in the works of the construction company Aitue, seeking to reduce their waste and purchase of material through new methodologies in the construction process.

Currently, there are studies on the analysis of the main material losses in building works (Bravo, 2018; Guarda, 2008) and economic quantification of construction waste (Bravo et al., 2019). Although there are also studies of economic optimization through waste reduction (Chandrakanthi et al., 2002; Patel and Patel, 2016; Wang et al., 2019), there are no finished studies of optimization of construction processes to avoid losses in Metalcon materials and gypsum boards.

1.1 Problem statement

The construction company Aitue SA, in charge of developing the San Andrés del Valle real estate project, has proposed to find a solution to the problem of plasterboard and Metalcon waste produced on site. In order to optimize its construction processes by implementing new technologies and methodologies, thus minimizing both the economic and environmental impact. The aim is to control the cubing and optimization of materials in the construction process and the waste generated in the different stages. In addition, to determine the increment value per unit of material under study, in order to know how these are increased in their final value due to the phases through which they must pass.

1.2 Description of the work

This study was carried out for Constructora Aitue SA in its extension building project called San Andrés del Valle Stage 7 (SAV7), located in the Tierras Coloradas sector, next to the Carriel Sur International Airport, near the Andalién River in the commune of Concepción, Bío Bío region, as can be seen in Figure 1. At present, the eighth stage is already under construction, with a projection of more stages within the sector.

Figure 1. Location of the project under study.

In the project, three different types of houses are built, with type C being the one under study, as can be seen in Figure 2, which has three bedrooms and a built area of 115.6 m^2. There are 12 houses of type C on the site (SAV7C). The materials analyzed in this study are used in partition walls, 2nd floor structural walls, and roof structure in the case of Metalcon, which in turn is mostly covered by plasterboard sheets in the interior lining of 2nd floor structural walls, partition walls, wet areas and ceilings. The windows are made of PVC split wood and equipped with thermocouple glass.

Figure 2. Study house type C (SAV7C).

1.3 Construction waste

Most of the waste generated in the construction process is the result of inadequate cubing at the design stage, which leads to the purchase of excess material, and poor management and use of materials during the construction stage. This leads to the unnecessary generation of waste at the construction site. The impact generated by solid construction waste is projected to reach at least 7.4 million tons by 2025 (Véliz et al., 2022). The metropolitan region alone contributes 31% of the total amount of solid construction waste in Chile, followed by the Valparaíso region with 7.1% and the Bío Bío region with 5.3%, due to the boom in real estate development in these regions (MMA, 2020).

2. Methodology

This study will address the proposed methodology to obtain the results with which an optimization procedure of the analyzed materials will be carried out.

2.1 Waste quantification

In order to estimate the amount of waste generated by the handling of the study materials, a field measurement of the waste generated was performed. This was done manually. The main objective of this stage is to know the percentage of waste with respect to the total amount of material for type C housing.

In the case of plasterboard sheets, the cubing was done by calculating the area of the pieces of waste and identifying their classification (RH 12.5 mm or ST 10 mm and 15 mm sheets), while for Metalcon, the cubing was done based on the lengths of the leftovers together with their classification (Profiles 60CA085, 62CA085, 90CA085, PORTANTE C.40R, 40CA085, 92C085 and 40 OMA085).

2.2 Life cycle of materials under study

Before carrying out an optimization process of the materials under study, it is necessary to know the value of the entire cycle per unit of each material analyzed. For this purpose, it is essential to know all the phases in which they are involved, considering the following stages:

(1) Purchase of materials

At this stage, the purchase of materials is quoted and carried out, depending on the quantity, since it can be partialized. The purchase price has a direct impact on the total value of the life cycle of the material, since if it is purchased in excess due to poor cubing or mishandling, it will also be considered a loss. Table 1 shows the purchase value of the materials under study.

Table 1. Cost of materials under study

Classes	Purchase value, $	Quantity
Gypsum plasterboard		
Volcanite ST 15 mm	3,990	58
Volcanite ST 10 mm	3,600	17
Volcanite RH 12.5 mm	6,784	15
Metalcon profiles		
Profile 60 CA085 6 m	3,895	11
Profile 62 CA085 6 m	2,669	16
Profile 90 CA085 6 m	5,057	68
Profile C.40 R 6 m	3,242	54
Profile 40 CA085 6 m	4,077	10
Profile 92 C085 6 m	4,414	37
Profile 40 OMA085 6 m	4,077	57

(2) Reception at the warehouse

Reception is supervised by the warehouse manager and an assistant, who are responsible for receiving, unloading and stocking the material.

(3) Transfer of material to the field

Material is moved with the help of a forklift and a foreman, supervised and authorized by the warehouse personnel.

(4) Material installation

The material installation process is paid to a subcontractor, who with a crew performs the cutting and installation of the material. The cost of this stage is not considered in the life cycle of the materials, since it is a job paid per house and not per unit of material.

(5) Cleaning of waste in the house

The cleaning of waste in the house is carried out, in the first instance, by two cleaning workers who collect the debris inside the house to maintain cleanliness inside, and then two other cleaning workers take all this waste out of the house to load it with the support of a backhoe, which will then move it to the waste collection sector, which is properly classified.

(6) Removal of construction site waste

The waste is removed with the help of two workers and the risk preventionist who supervises the loading of the waste by the transport company, which is then taken to destinations such as the scrap purchase plant in the case of Metalcon profiles and the treatment plant in the case of gypsum plasterboard. After identifying the stages through which the material passes, we proceed to perform field measurements, measuring the delay time for each of the stages of the material that is used in type C housing.

2.3 Software used

The software used to carry out the optimization study of the analyzed materials is presented below.

(1) CutMaster 2D

For the development of this study, the CutMaster 2D (2015) software is used, which optimizes the dimensioning of the materials, in turn generating a smaller amount of waste as a result of the good use of the material. Although there are several softwares that can solve the problem in question, in this study the aforementioned program is used.

The defined cut is vital for the optimized production of parts, with the least amount of waste, where the CutMaster 2D (2015) software provides all the tools to achieve the maximum yield of the material. In the main screen of the program, the input data are entered, such as material dimensions and the dimensions of the required cuts, as can be seen in Figure 3.

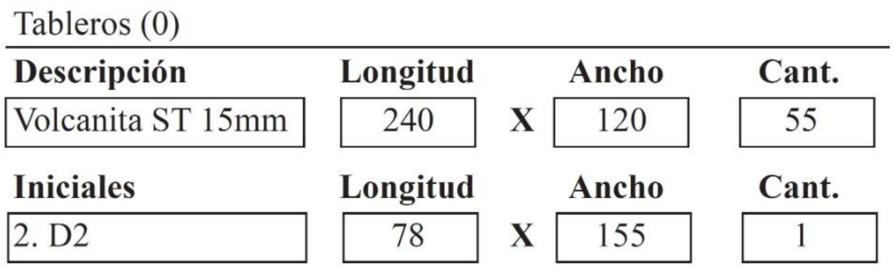


Figure 3. Example of entering material input and cutting data into CutMaster 2D program.

The program will generate an iterative process until it delivers the best proposal of required cuts based on the input data, as shown in Figure 4. It also provides relevant information regarding the percentage of utilization per material, average utilization per total material, amount of waste generated, cutting plans, among other relevant data, as shown in Figure 5.

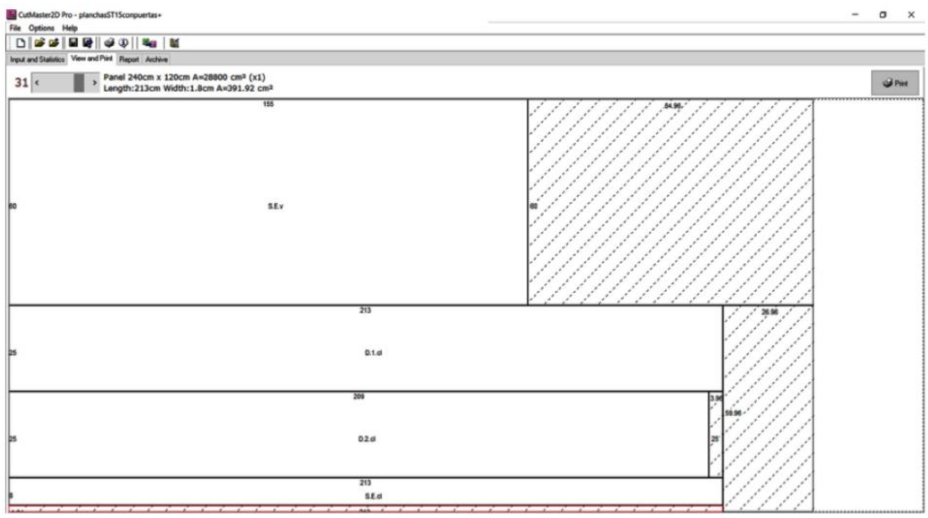


Figure 4. Example of cutting plan delivered by the CutMaster 2D software.

Parts entered	146
Used parts	146
Used boards	51
Area of parts (cm^2)	1,397,982
Average profit	95.18
Utility of last board (%)	77.8
Cutting length (cm)	34,856.08
Edge length (cm)	0

Figure 5. Example of statistical data computed by the CutMaster 2D software.

(2) SketchUp

Another program used within the study is the software SketchUp (2017), from where 3D modeling is performed to subsequently create an installation manual with the cuts of plates and in turn, optimize their cuts graphically, since it is a graphical representation of the material already installed. In this way, the installation methodology can be standardized and shown to the workers on site, since it allows a better understanding than the models currently used in 2D.

For the graphical representation of the house, it is necessary to have the structural drawings updated to their latest version and thus to transfer these dimensions to the software, obtaining a 3D modeling as close to reality as possible, as can be seen in Figure 6.

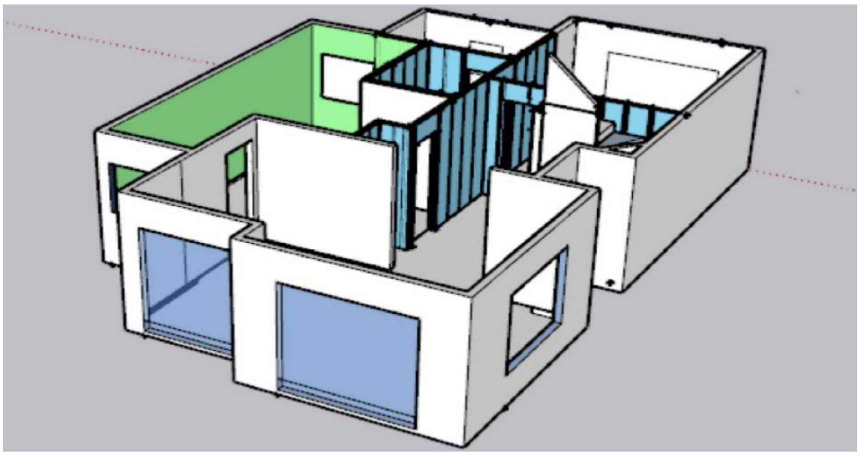


Figure 6. 3D modeling of the 1st floor of type C dwelling using SketchUp.

3. Waste Cubing

The following sections show the results of the cubing of plasterboard and Metalcon waste that is currently on the site for house type C. Table 2 shows the cubic meters of plasterboard waste and the total area of material destined for the house, obtaining the percentage of waste with respect to the material destined for the house.

Table 2. Cubing of gypsum plasterboard waste

Classes	m^2 destined	Quantity of waste, m^2	%
Volcanite ST 15 mm	167.04	16.64	10
Volcanite ST 10 mm	48.96	7.48	15
Volcanite RH 12.5 mm	31.68	6.43	20

Table 3 shows the cubic capacity in kilograms of Metalcon waste and the total material destined for the house, obtaining the percentage of waste with respect to the material destined for the house.

Table 3. Cubing of Metalcon waste

Classes	kg for the house	Quantity of waste, kg	%
Profile 60 CA085 6 m	360.6	25.9	7
Profile 62 CA085 6 m	69.1	4.3	6
Profile 90 CA085 6 m	879.7	214.4	24
Profile C.40 R 6 m	123.1	9.3	8
Profile 40 CA085 6 m	49.8	7.7	15
Profile 92 C085 6 m	222.0	17.8	8
Profile 40 OMA085 6 m	330.4	26.1	8

It is worth mentioning that 20 residue profiles were counted that exceeded 1 m in length, with the longest profile reaching 1.81 m. The average length of the residues was 69.8 cm. The average length of the residues was 69.8 cm.

4. Material Evaluation

4.1 Life cycle of the materials under study

Based on the phases identified above, the results of the time required for each activity involved in the life cycle of the plasterboard sheets are shown in Table 4, and in Table 5 for the life cycle of the Metalcon profiles.

Table 4. Delay time for the totality of sheets

Activity	Resources	Time, min
Reception at the warehouse	Warehouse manager	40
	Labor	40
	Forklift+operator	40
Transfer of material to the field	Workday	78
	Backhoe + operator	24
Cleaning of waste in the field	2 cleaning shifts	48
	2 daily wages	37
	Backhoe + operator	25
Removal of waste	Preventionist	0.34
	2 days	0.34

Table 5. Delay time for the totality of profiles

Activity	Resources	Time, min
Reception at the warehouse	Warehouse manager	30
	Workday	30
	Forklift Manitou + operator	30
Transfer of material to the field	Workday	33
	Forklift Manitou + operator	23
Cleaning of waste in the field	2 days of cleaning	34
	2 days	30
	Backhoe +operator	30
Removal of waste	Preventionist	0.24
	2 days	0.24

4.2 Valuation of the material cycle

After obtaining the times necessary to perform each activity, a cost is added to this cycle of the materials under study, which is calculated, considering the salaries of the workers as shown in Table 6 and the costs of the machinery as shown in Table 7. These costs are valued per minute to unify the units of measurement.

Table 6. Valuation of labor

Worker	$/month	$/day	$/h	$/min
Warehouse manager	660,000	22,000	2,750	46
Laborer	450,000	15,000	1,875	31
Preventionist	700,000	23,333	2,917	49

Table 7. Valuation of machinery

Machinery	$/h	$/min
Backhoe loader	16,000	267
Manitou	15,700	262
Forklifts	16,000	267

It is worth mentioning that the cost for both materials is added to the cost of transport for waste removal and landfill. In the case of cardboard gypsum, it is transported to the HIDRONOR treatment plant located in the municipality of Florida, Bío Bío region. The costs are as follows:

- Cost of transportation from construction site to landfill: $150,000
- Cost per kilo of plasterboard waste reception (c/IVA): $70

In the case of Metalcon, it is purchased by a scrap treatment company, which includes transportation, with the following values:

- Purchase price per kilo: $120

From all the above data, the results of time in each of the phases can be transferred to an associated cost for each type of material. The phases of reception in the warehouse and transfer of material to the field are grouped under the item cost of labor and machinery. In addition, the phases of cleaning in the field, removal and the cost of waste treatment are grouped under the waste disposal cost item. Table 8 shows the life cycle value of the gypsum plasterboard sheets.

From all the above data, the time spent in each phase can be converted into an associated cost for each material type. The phases of receiving materials in the warehouse and transferring them to the field are grouped under the cost of labor and machinery. In addition, the phases of cleaning in the field, removal, and waste treatment costs are grouped under waste disposal costs. Table 8 shows the life cycle value of the gypsum plasterboard sheets.

Table 8. Life cycle value of a gypsum wallboard sheet

Life cycle value of a gypsum wallboard sheet				
Type	Purchase value	Cost of labor and machinery, $/plank	Cost of waste disposal, $/plate	Total valor material
Volcanite ST 15 mm	3,990	371	4,411	8,772
Volcanite RH 12.5 mm	3,895	371	3,712	7,978
Volcanite ST 10 mm	3,600	371	3,155	7,126

Table 9 shows the life cycle value of Metalcon. It is worth mentioning that the cost of waste in the case of this material is negative, since it is not an expense for the construction company, but the material purchased by the waste disposal company, so its value is still the income of the construction company.

Table 9. Total value of Metalcon material

Life cycle value of a Metalcon profile				
Type	Purchase value	Cost of labor and machinery, $/profile	Cost of waste disposal, $/profile	Total material value
Profile 60 CA085 6 m	3,895	50	-409	3,536
Profile 62 CA085 6 m	2,669	50	-306	2,413
Profile 90 CA085 6 m	5,057	50	-523	4,584
Supporting profile C.40 R 6 m	3,242	50	-159	3,133
Profile 40 CA085 6 m	4,077	50	-351	3,776
Profile 92 C085 6 m	4,414	50	-424	4,040
Profile 40 OMA085 6 m	4,077	50	-414	3,713

5. Optimization Proposal

The step-by-step methodology proposed for the optimization of the materials under study is explained below.

(1) Plasterboard

As a first step, it is necessary to perform a 3D modeling of plans in programs enabled for such activity, in this study

SketchUp (2017) was used. The different housing typologies are modeled, including the Metalcon structure in order to make an optimization of plasterboards as close to reality as possible, as shown in Figure 7. For this first step, the architectural and detailed plans of Metalcon of each house typology, in its latest version, are needed.

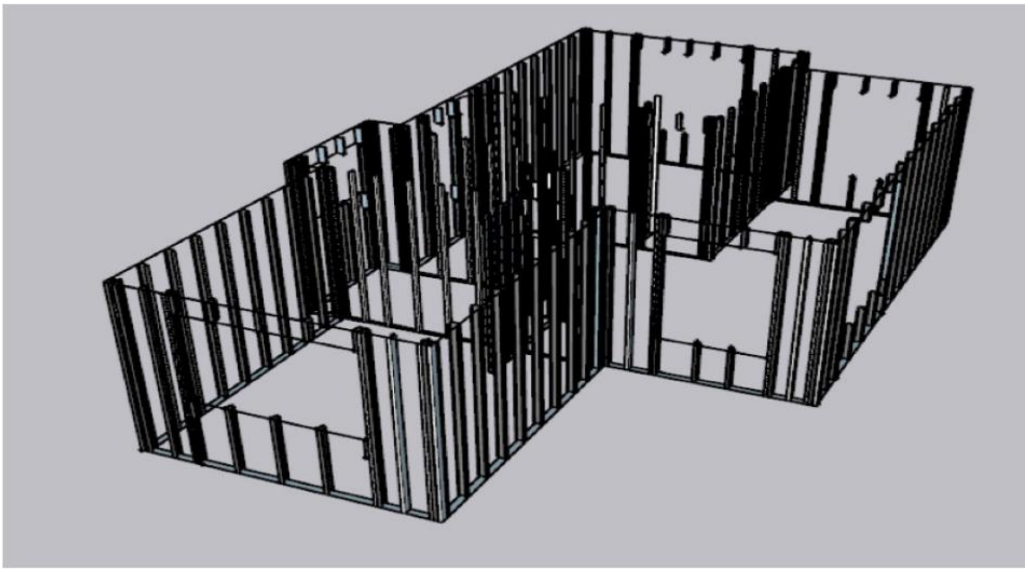


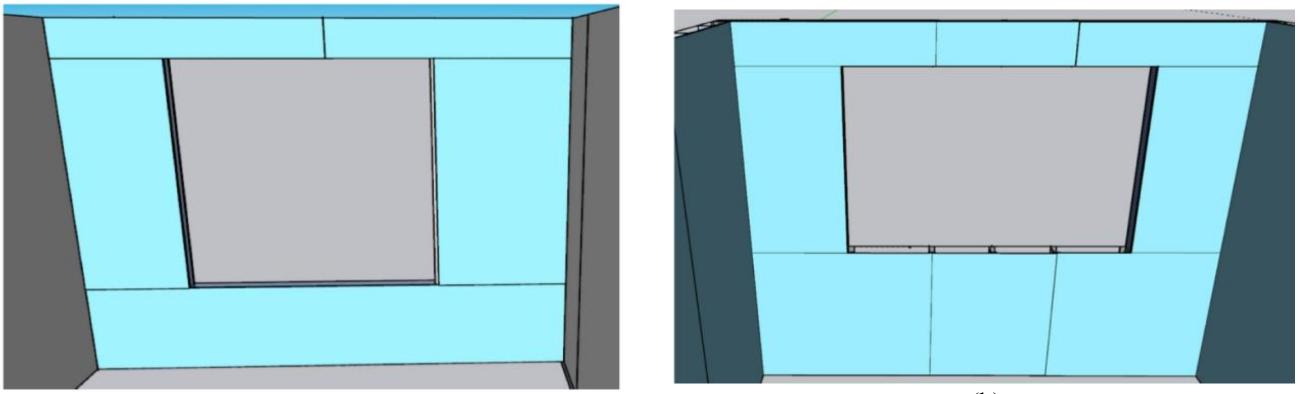
Figure 7. 3D modeling of 2nd floor of dwelling type C.

Secondly, the CutMaster 2D (2015) program is used to optimize the sizing of the plates, with the methodology described below.

(1) Starting from the corner, install the entire sheets on smooth walls without doors and windows. Before performing planks cutting, perform this step on the entire house.

(2) Starting from the corner, install the full planks in the closet. Before performing the planks cutting, perform this step on the entire house.

(3) Then start with the installation of the planks in window openings, two types of cuts are proposed depending on the dimensions of the window. The first case is to make rectangular cuts of greater length, as shown in Figure 8a, and for the second case with larger window dimensions, the solution of cuts with greater area is proposed, as shown in Figure 8b.



(a) (b)

Figure 8. Proposed cuts in window openings: a) less cuts for larger window and b) more cuts for smaller window.

Subsequently, continue with the door openings. In this case, it is recommended to make rectangular cuts and to use the pieces of plates from the previous points. Figure 9 below shows an example of how to make the cuts for doors.

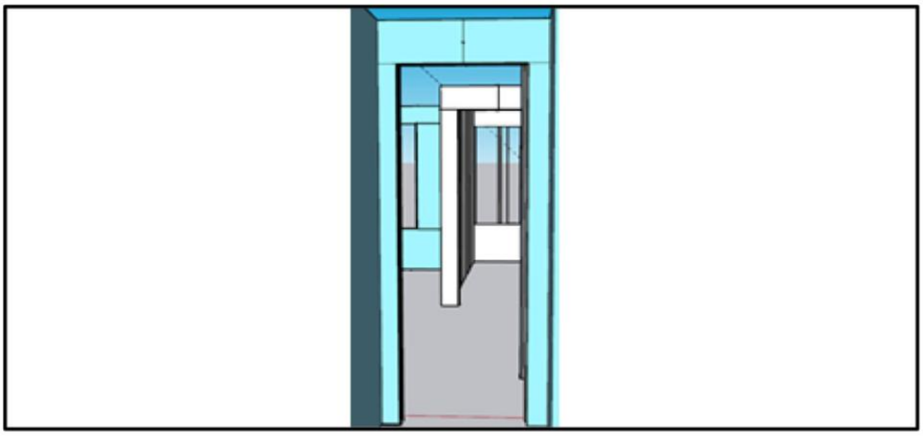


Figure 9. Proposed cuts in door openings.

All the excess cuts from the aforementioned stages, rectangular or irregular (interior of closets, shafts, finishes, among others) must be returned to the optimization process through the CutMaster 2D software (2015), in order to optimize the largest number of pieces in the available sheets. To finish this process, an installation manual will be created to show the different layouts of the plasterboard sheets that will be used in the type C house. This manual will be used for the field installation, a process that must be repeated to optimize all the cuts depending on the type of house.

(2) Metalcon

A Metalcon cubic dimensioning is made as detailed as possible, considering the material to be used in both the roof structure and the partition walls of the house. In this way, the cuts are made unifying both items, thus generating an optimization as a whole, since currently the cuts are made separately and depending on the construction stage of the house, without taking full advantage of the material and generating more waste.

Then, the data that were previously grouped are entered into the CutMaster 2D (2015) program, keeping the width constant and only varying the lengths as shown in Figure 10. The program will calculate the best combinations of the cuts to achieve the best optimization of the cuts. In addition, it delivers the result of the combinations graphically as shown in Figure 11.

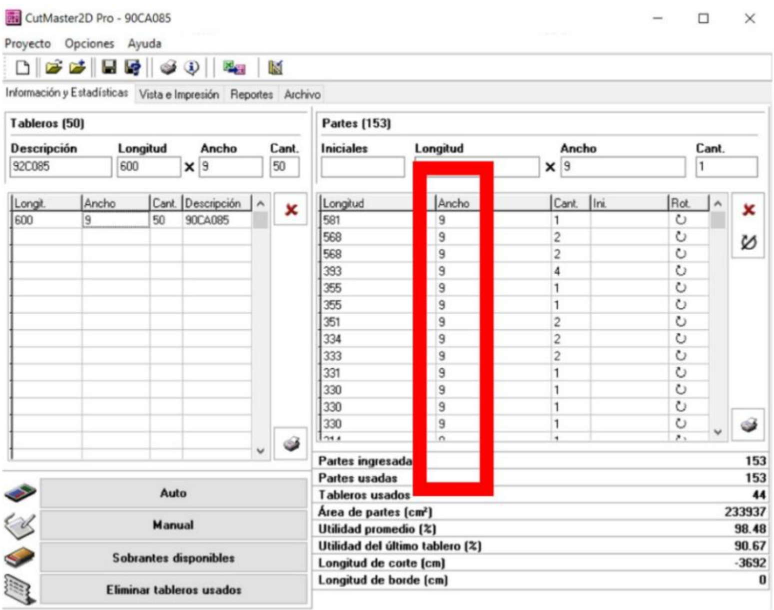


Figure 10. Data input to CutMaster 2D constant width (highlighted in red).

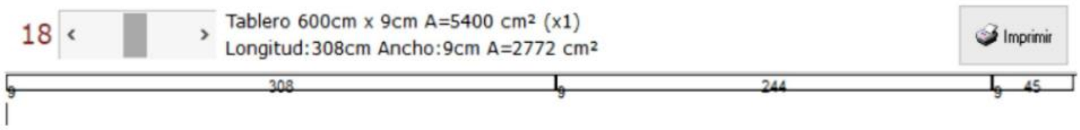


Figure 11. Cutting plane delivered by the software.

6. Verification of the Material Optimization Methodology and Waste Reduction Methodology

6.1 Verification of the material optimization methodology

Based on the methodology proposed for the study materials, the results are analyzed to determine whether the use of the materials can be effectively optimized. Table 10 shows the amount of material that can be effectively reduced with the new methodology.

Table 10. Comparison of quantity of material used

Material	Materials currently used	Material to be used with new methodology
	Plates	
Volcanite ST 15 mm	58	52
Volcanite ST 10 mm	17	17
Volcanite RH 12.5 mm	15	12
Material	Profiles	
Profile 60 CA085 6 m	11	10
Profile 62 CA085 6 m	16	14
Profile 90 CA085 6m	68	50
Supporting profile C.40 R 6 m	54	54
Profile 40 CA085 6 m	10	10
Profile 92 C085 6 m	37	27
Profile 40 OMA085 6 m	57	57

Although some materials cannot be reduced, other materials are possible, such as the volcanite ST 15 mm and volcanite RH 12.5 mm in gypsum board, as well as the 60CA085, 62C085, 90CA085, and 92C085 profiles in the case of Metalcon, which can indeed be reduced using new methods.

6.2 Verification of waste reduction methodology

In the next phase, the study will focus on the materials that can be optimized. By reducing the amount of material to be used, their waste will also be reduced. Table 11 shows a comparison of the percentage of waste currently generated with that generated by the new methodology.

Table 11. Residue comparison

Material	% of waste currently	% of waste with new methodology
Volcanite ST 15 mm	10	3
Volcanite RH 12.5 mm	20	10
Profile 60 CA085 6 m	7	4
Profile 62 CA085 6 m	6	5
Profile 90 CA085 6 m	23	6
Profile 92 C085 6 m	8	5

Table 11 shows that it was possible to reduce waste by 74% in the case of profiles 90 CA085 6 m and by 70% in Volcanite ST 15 mm, which would imply savings in the purchase of materials for the construction company and, at the same time, make the construction site cleaner.

7. Comparison of Life Cycle Value and Cost of Materials

7.1 Comparison of life cycle value of materials

Based on the value obtained in the previous section, which is the estimated value of the material cycle, the total value per unit of material has been determined. Compared to the purchase value per unit excluding the lifecycle, the increase can be calculated. In the case of plasterboard, Table 12 shows the percentage increase in price, in some cases exceeding 220% of the initial purchase value, as in the case of Volcanite RH 12.5 mm type.

Table 12. Increase in the purchase value of gypsum plasterboard, including the life cycle

Type	Purchase value, $	Total material value, $	Increase
Volcanite ST 15 mm	3,990	8,772	220%
Volcanite RH 12.5 mm	3,895	7,978	205%
Volcanite ST 10 mm	3,600	7,126	198%

In the case of Metalcon, its life cycle is totally different. As can be seen in Table 13, there is no increase in the final value of the different types of profiles; rather, their value is reduced due to the sale of these wastes, which is why the final value of the material is less than the purchase price.

Table 13. Decrease in the purchase value of Metalcon

Type	Purchase value, $	Total material value, $	Decrease
Profile 60 CA085 6 m	3,895	3,536	9%
Profile 62 CA085 6 m	2,669	2,413	10%
Profile 90 CA085 6 m	5,057	4,584	9%
Supporting profile C.40 R 6 m	3,242	3,133	3%
Profile 40 CA085 6 m	4,077	3,776	7%
Profile 92 C085 6 m	4,414	4,040	8%
Profile 40 OMA085 6 m	4,077	3,713	9%

It should be noted that the increase in the purchase of materials includes the final price, considering the life cycle obtained in the section material cycle valuation. Therefore, it is necessary to optimize the total purchase of materials with a cubing according to the new proposed methodology, in order to reduce the final price for the entire item.

7.2 Cost comparison

By reducing the amount of material with the new optimization method, the total purchase of materials is also reduced, generating an initial monetary saving and, consequently, a reduction in waste. Tables 14 and 15 show a summary of the differences between the current method and the optimized proposal, where the differences in both material purchase costs and waste costs are evident.

Table 14. Comparison of costs of gypsum plasterboard sheets

Current method						
Type of sheet	Number of plates	Value of plate, $	Total purchase cost, $	Waste, m^2	Value of waste per plate, $	Value per total waste, $
Volcanite ST 15 mm	58	3,990	231,420	16.64	4,196	24,243.56
Volcanite RH 12.5 mm	15	6,784	101,760	6.4	3,497	7,771.11
		Total purchase	333,180	Waste recovery		32,015
Optimized proposal						

Type of sheet	Number of plates	Value of plate, $	Total purchase cost, $	Waste, m^2	Value of waste per plate, $	Value per total waste, $
Volcanite ST 15 mm	52	3,990	207,480	5	4,196	7,284.72
Volcanite RH 12.5 mm	12	6,784	81,408	1.5	3,497	1,821.35
		Total purchase	288,888	Waste recovery		9,106

Table 15. Cost comparison metalcon profiles

Current method						
Profile type	Number of profiles	Profile value, $	Total purchase cost, $	Waste, kg	Residual value per profile, $	Value per total waste, $
Profile 60 CA085 6 m	11	3,895	42,845	25.90	-409	-1,839
Profile 62 CA085 6 m	16	2,669	42,704	4.55	-306	-322
Profile 90 CA085 6 m	68	5,057	343,876	89.39	-523	-6,335
Profile 92 C085 6 m	37	4,414	163,318	17.80	-424	-1,258
Total purchase			592,743	Waste recovery		-9,754
Optimized proposal						
Profile type	Number of profiles	Profile value, $	Total purchase cost, $	Waste, kg	Residual value per profile, $	Value per total waste, $
Profile 60 CA085 6 m	10	3,895	38,950	10.8	-409	-767
Profile 62 CA085 6 m	14	2,669	37,366	3.4	-306	-241
Profile 90 CA085 6 m	50	5,057	252,850	54.9	-523	-3,891
Profile 92 C085 6 m	27	4,414	119,178	11.1	-424	-784
Total purchase			448,344	Waste recovery		-5,683

(1) Plasterboard

Based on the results in Table 14, the total savings for dwelling type C, for gypsum plasterboard material, are shown:

- Savings for dwelling type C: $44,292
- Savings for a total of 12 Type C dwellings on site: $531,504
- Waste savings for dwelling type C: $22,909
- Waste savings for a total of 12 Type C homes: $274,908

Obtaining a total savings of $806,412 pesos for the total of type C houses.

(2) Metalcon profiles

Based on the results in Table 15, the total savings for housing type C for the Metalcon material are shown:

- Savings for dwelling type C: $144,339
- Savings for a total of 12 type C dwellings on site: $1,732,788

In the case of Metalcon waste savings, it is not a value that the construction company can save, because by reducing its waste, the sale of this material decreases, which is why the value is negative in the total value of waste column. However, the purchase savings with the new methodology is $1,732,788 pesos for all type C houses.

8. Comments and Recommendations

It is necessary to train project engineers, technical office engineers or others involved in the design and cubing stage in the use of CutMaster 2D (2015) and SketchUp (2017) software, in addition to training the site personnel working on the installation, in order to implement the new methodology. This is due to the fact that this methodology does not only depend on the executors of the work, but should be pre-designed from the conception of the project.

In the case of plasterboard, it is recommended that a cutting and sizing workshop be created within the site facilities to cut the sheets for all the houses. This workshop should have a crew dedicated only to cutting sheets and coding each cut to be identified in the field installation process, accompanied by an easy-to-read manual for the master installers. When making the cuts at the construction site, the masters must verify if the dimensions of the houses are the same as projected and make the changes before proceeding with the cuts, in order to avoid unforeseen events during the installation stage.

In order to implement Metalcon's new methodology, it is recommended that a precast workshop be created within the site facilities. This shed will be used to build Metalcon's prefabricated structures, which would allow better use and optimization of resources, both in terms of installation time and materials. This should be done by a crew dedicated only to building the Metalcon structures. It is recommended that the prefabricated structures be moved by machinery and assembled by another crew. In the proposed workshop, by prefabricating in a controlled environment, waste can be accounted for, which favors the reuse of the materials under study and others used on site.

It is recommended to generate a protocol for handling all construction site waste, so that all excess material is classified and reused when appropriate.

9. Conclusions

It can be concluded that the new proposed methodology generates savings in the purchase of materials and a reduction in the generation of waste, obtaining both economic and environmental benefits. Moreover, since the increase in the final value of the materials has been evidenced considering the purchase and their life cycle, it is essential to optimize these materials in the design, cubing and installation stages in order to avoid unnecessary purchases that sometimes increase their final value by up to 220%. On the other hand, by implementing a cutting and sizing workshop on site, it is possible to assume a reduction in the time required to perform these operations, since the prefabricated materials can be produced in a process line that optimizes the manufacturing time and regulates the amount of material to be used. Finally, it is feasible to extrapolate the proposed methodology to other construction materials that must be sized on site, such as plywood, melamine, tiles or others.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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