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PRODUCT PLATFORM FLOW TO DEVELOP NEW PRODUCTS IN AN OFF-SITE COMPANY

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ABSTRACT

The civil construction's cost has increased since the beginning of the pandemic, bringing insecurity to the sector. In addition, civil construction is largely responsible for environmental impacts related to greenhouse gases and waste generated globally. Several industries, such as the auto industry, use the product platform concept to optimize their processes, bringing more efficiency and control to their productions and products. The existing theory on the application of a product platform in construction shows that it can be a means of controlling fluctuating costs and reducing environmental impacts, but there is a gap, with few studies showing the application in real cases and the gains obtained. To assess this, the literature review aims to understand how product platforms work in other industries and what we have so far on their application in the construction sector. An action research method is used, applying the product development flow created, to meet two demands for new products in the studied company, using other platform solutions already developed by the company – such as application of common items - to achieve cost reduction. The result of the practical application reached the company's expectations, achieving a significant cost reduction.

KEYWORDS

Product development, product platform, off-site construction, industrialized construction, standardization.

INTRODUCTION

From January 2020 to January 2022, the annual increase cost of Brazilian civil construction more than doubled in relation to the period from January 2018 to January 2020, as can be seen in Figure 1 (FGV, 2022). And even though the index shows a reduction in 2022, it is still considerably above the index in the pre-pandemic years. According to European Commission (n.d. a) data on construction cost indexes, in Europe, between 2011 and 2016, cost increases were around 1.5% per year, from 2017 to 2019 around 2.3% and even though in 2020 it kept stable, in 2021 the cost increase in construction averaged 6.5%.

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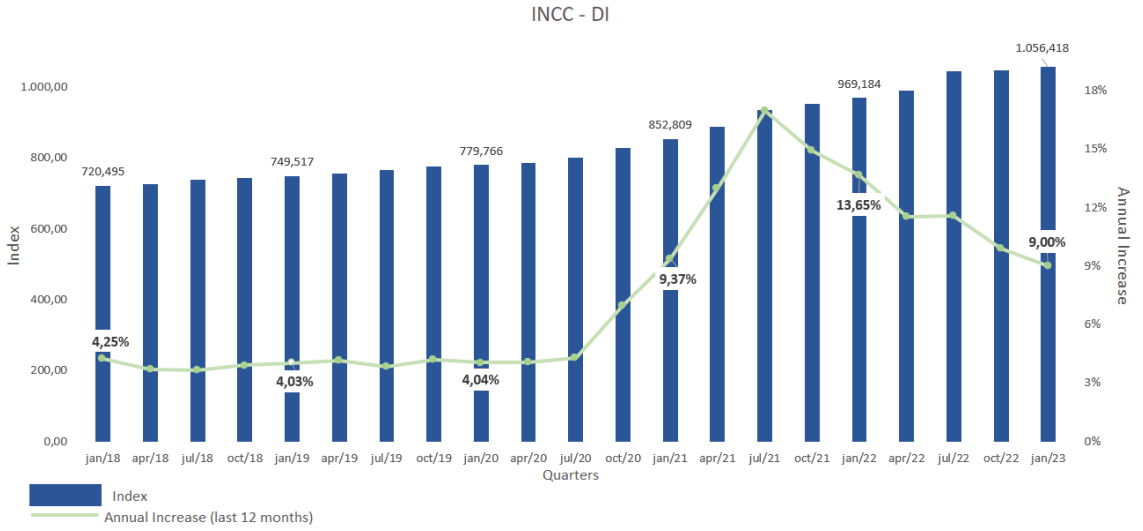

Figure 1: National Civil Construction Index (INCC) variation. Adapted from FGV, 2022

Besides, constructions and demolitions are responsible for 44% of the waste produced by industrial sectors annually (Chen et al., 2022). Along the same lines, Liu et al. (2015) report that in England, activities related to construction and demolition are also responsible for 44% of all waste generated. On a global scale, around 40% of the material dumped in landfills is construction waste (Banihashemi et al., 2018). Waste means extra cost to the construction companies and residents.

The product platform is a strategy widely used in manufacturing such as the automobile industry (Alizon et al., 2009), it consists in identifying commonalities that can be applied to more than one project, product, or process, with the aim of creating and grouping common items (components, processes, knowledge, and people). The creation of standardizations allows product derivatives to be developed and produced more efficiently (Popovic et al., 2021 and Hanafy et al., 2017), that includes standard processes as well. Furthermore, studies such as that by Tseng et al. (2008) show how modular design and '*platformization*' can lead a product to a more sustainable lifecycle.

The existent literature brings a solid theoretical approach on general product platforms, but there are few studies showing the application in real cases and the gains obtained. This research addresses this existing gap by using the Action Research Methodology, identifying through existing literature ways in which the use of product platforms can address the cost challenges, bringing with it a gain in sustainability and then creating a new product development flow based on the reviewed literature, and applying it in the company's process observed in this study, to capture the real gains in cost reduction with the use of product platform solutions.

PRODUCT PLATFORM

The clustering of different assets (e.g., components, processes, knowledge) in order to define standards that will be used in the creation of new products is the basic concept of a product platform (Robertson et al., 1998). As Lennartsson et al., (2018) described, “Through product platforms, companies achieve high levels of product variety, a reduced time to market, improved operational efficiency and responsiveness to market needs”.

Standardization also has benefits related to a company's supply chain. As shown by UK Research and Innovation & Construction Innovation Hub, 2022, the constant and repeated use of the same components brings three main benefits:

1 – allows working with stock, which allows companies to take advantage of promotions or cost reductions to control their own production costs;

2 – allows the development of different suppliers for the same element, limiting the market control of only one supplier, which normally means high cost;

3 – reduces the risk of delays resulting from a long lead time from suppliers.

These risks of delay in the conventional construction process (due to project delays or material delivery) are further compounded by delays related to low productivity, lack of labour, and operational stoppages (strikes, absences, delays) (Bryden Wood et al., 2018). These risks are minimized or eliminated with the adoption of platform strategies.

All the benefits mentioned above can be converted into financial gain, as presented by Bryden Wood et al. (2018). The net present value (NPV) – which is the cash flow assessment of an investment in a given period – in a process with a platform approach is optimized by requiring a smaller initial investment, reducing the time to payback on this investment and increasing the value end when compared to a conventional process.

A successful platform requires a balance between custom elements, unique to each project and impossible to avoid, complementary elements, which are similar but not the same (such as colour or material variation), and standard elements, common to all projects. This balance allows companies to meet the desires of their customers (UK Research and Innovation, 2022).

The use of standardization is not unknown for general manufacturers, such as the automobile industry (Alizon et al., 2009). Within this type of industry, the customization of the final products - cars and trucks, for example - by the end customer does not involve structure, such as chassis. Their customizations include colour, electric windows and air conditioning systems, for example, that does not – or have minimal - change the production line. In civil construction, the case is different, the end customers are residents, and they tend to want a personalized house, often designed exclusively for them (Gibb, 2001). This makes the standardization process more complicated to the production line, and to address this point, there is the mass customization strategy.

MASS CUSTOMIZATION

Mass customization is a technique that firstly involves in-depth knowledge of the customer to meet their specifications using standard assets that, combined with each other, bring customization of the final product without losing scale economies (Duray et. al, 2000). A good example of this is the computing industry, which has standard modules (video cards, batteries, memory cards) that when combined can form different end computers, serving customers looking for the simplest to the most complex computers capable of running heavy software (Piller et. al., 2006).

In civil construction, mass customization can work through the architectural modularization of roof types, window and door frames, and hydraulic kit solutions, one can even think of the spatial modularization of entire environments, such as kitchens and bathrooms, even transforming electrical and hydraulic elements in default. Figure 3, below, shows standardized solutions, that combined in different ways can create different products, and helps to better understand this idea.

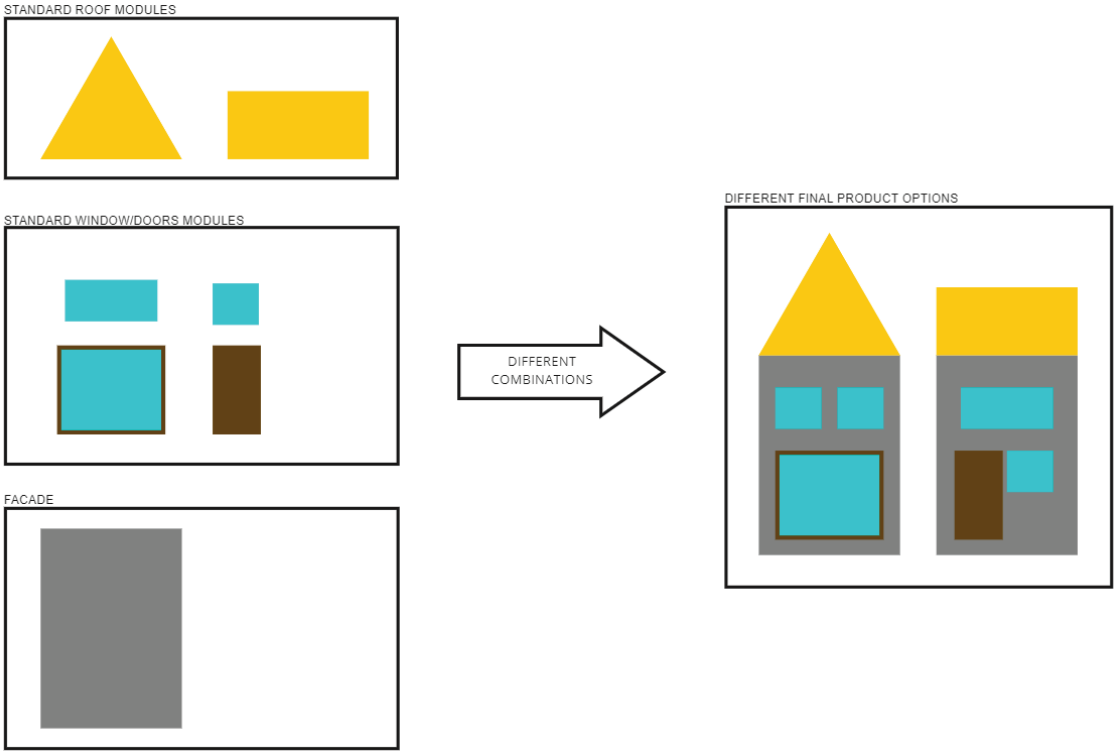

Figure 3: Mass customization in civil construction

The use of mass customization and product platforms is related to sustainability through increased efficiency since the teams that work in production only work with the repetition of modules, thus, they are able to specialize and continuously improve in what they are doing. This reduces errors, therefore reducing rework and therefore reduces the use of raw materials. Also, the participation of the customer reduces or eliminates the reforms, which reduces the waste generated with them (Rocha, et al., 2015).

In addition, as Gibb (2001) demonstrated in his case study, the repetition of modules, solutions, and processes reduces the work of the project team and brings more efficiency to the engineering team, and reduces costs and risks related to accidents at work and delays. This information is corroborated by UK Research and Innovation & Construction Innovation Hub (2022).

The greatest gain with the use of the platform exists when its application happens from the product development phase when the conception of a new product is done collaboratively with commercial, project, operational, and supply chain teams (Ortega *et al*., 2022). And integrating all stakeholders in the design stage is a challenge within civil construction (Jaillon & Poon, 2010), but it is fundamental for the success of a product (Ortega *et al*., 2022).

Make to Order and Configure to Order

Inside a platform, the products can be placed in different categories. A new product that is fully developed (e.g., complementary projects, DfMA) before being launched in the market, fits into the Make-to-Order (MTO) category. MTO products cannot be modified by the customer, they are adamant about changes. But mass customization allows some modifications to meet customers' specifications, in this case, when a new product is developed based or not on a previously existent project, but still only uses solutions and processes that belong to the platform, they are called Configure-to-Order (CTO). Figure 4, based on Gatehouse.design (n.d.), shows the different categories, and the line is the decoupling point of the customers' specifications – the further to the right, the more specifications are created in the development

phase, before the customer order, and to its left, more specifications are created following the customer order, customized.

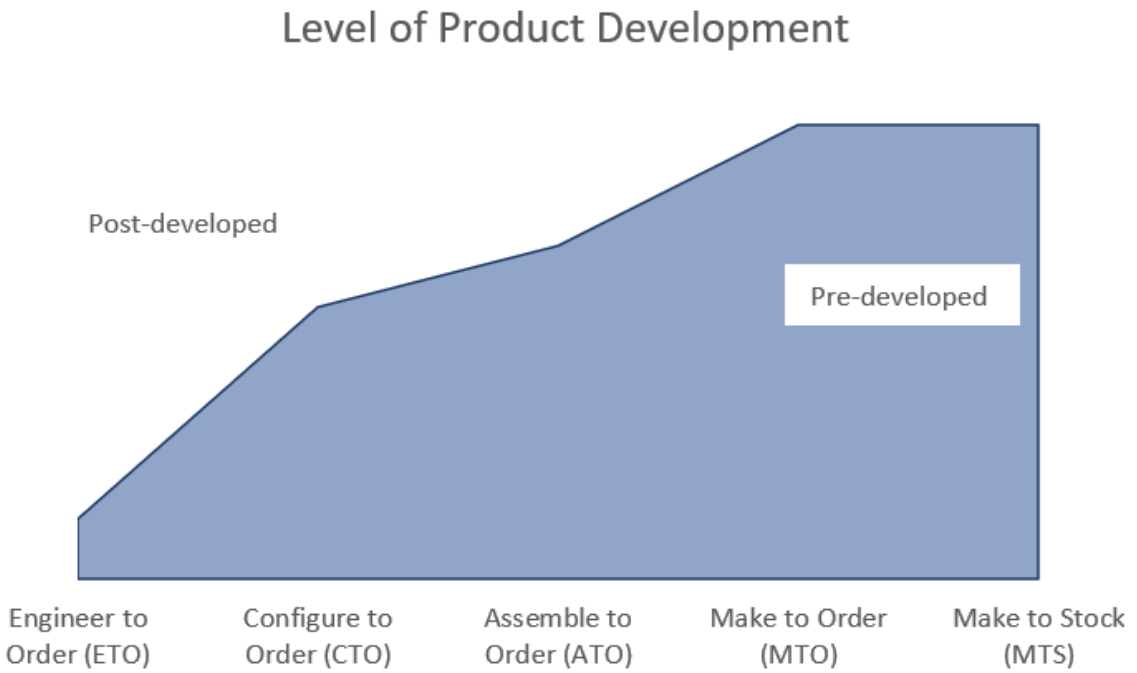

Figure 4: Customer Order Specification Decoupling Point

PRODUCT DEVELOPMENT FLOW

A new product development flow was proposed and put into practice within an offsite company in Brazil, called Company A, seeking to involve all stakeholders from the beginning of the process. The company is changing its way of creating new products, looking for more efficiency in its processes and operations.

As one of the authors works in Company A, it was possible to apply the Action Research (AR) method. The company's internal demands call for speed in changing processes, and according to O'Brien (2001), AR is suited to cases like this. It also was possible to apply multiple interactive cycles to reach the flow used, aiming to put into action all the research made on creating new products in a product platform strategy (Conte et al., 2022).

Initially, Company A didn't have a consolidated flow to develop new products, and the process was disintegrated. Figure 5 shows the proposed new product development's flow, that was created from the observation of all stakeholders involved in the process, how many times and at what moments they were involved and gave inputs in the process - it was common for an interested party to decide to change something in the product after it had already been budgeted, causing rework. Based on this, an analysis was carried out seeking to reduce the number of times that a stakeholder is involved to provide inputs, involving him only at the right moment of decision making.

The flow starts with a commercial demand – that can be a new product or a customization of an existing one - united with the constraints of the platform in which it fits. The platform is the clustering of the standard solutions that can be used, and a product with these solutions belongs to said platform. These two things are the trigger to start the development of the architectural project, which goes through evaluation by the commercial team, evaluation by the engineering team, and general evaluation in a back-and-forth cycle until it is approved by all.

With general approval, the product's CTO budget is drawn up, within a flexible spreadsheet that allows for project changes. If the cost is not approved, it goes back to the development of the architectural project. If it is approved, the process has a decoupling point, from which nothing in this product can be changed after all the necessary validations were made – *this decision-making point with no possibility of return brings more seriousness to the evaluations and avoids rework*. After that, begins the preparation of the commercial material for launch on the market, in parallel with the development of a details book that aims to identify the materials that have the most critical delivery lead time. The product remains in the portfolio until a sale takes place. With the sale and with the details book, the executive projects (e.g., complementary, production, assembly) and the final DfMA of the product are made. With all the projects ready, the final bill of materials is made, which is then passed on to the supply chain team, and this product becomes MTO.

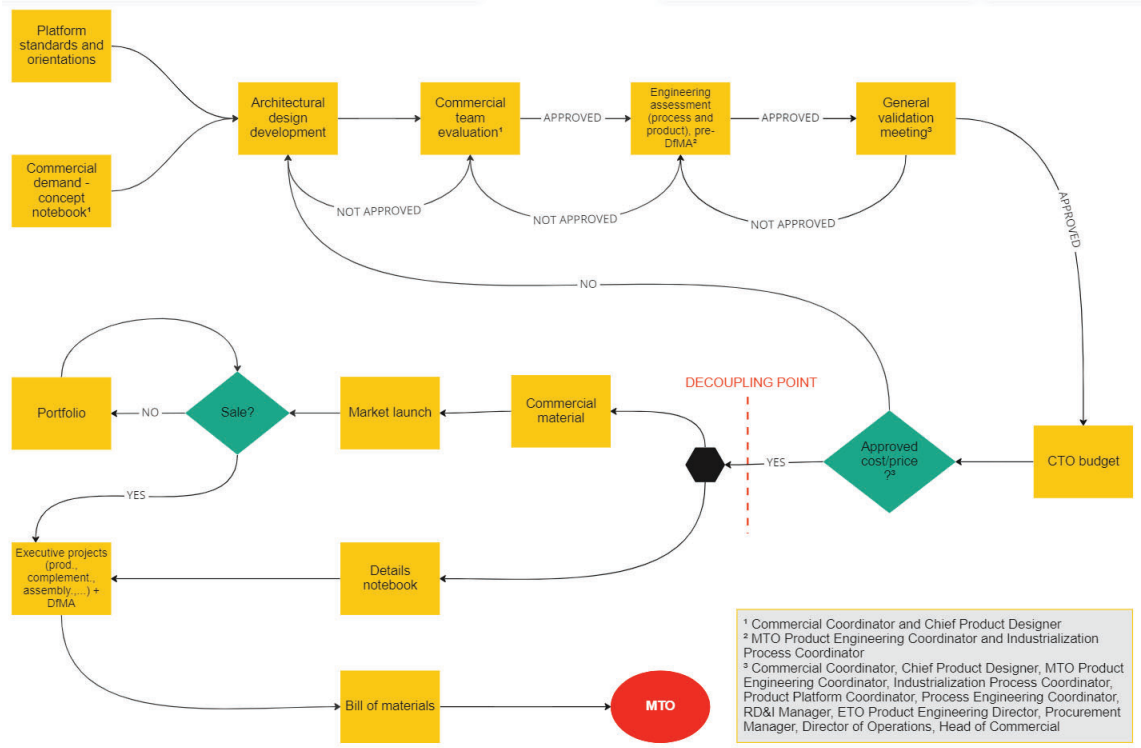

Figure 5: Integrated New Products Development's Flow

This flow takes place within any created platform, and the creation of platforms within the company takes place from the identification of needs that are not met with the existing ones, that means that if some products need solutions that are not part of an existing platform, it can be the case to create a new one based on commercial demand. For the creation of a new platform, Company A has an RD&I team that has the function of bridging the gap with the commercial team to understand new market demands, assess whether these demands can be met with existing solutions and elements or not. If not met, new solutions are studied, prototyped, evaluated and validated to become, then, a new platform.

With this flow, any changes in an already existing product can be easily and quickly met. So, if a customer wants an existing product (MTO), but with bigger rooms, or a different set of windows, for instance, he can have. His product will start as CTO and will belong to the platform characterized by the solutions and standardization used. As the solution for the company will be the same, and the client will have the desired modification, it can be said that the company has now adapted its process and caters to mass customization.

APPLICATION

The product development process shown above in Figure 5 was applied in the development of two new products in Company A, with solutions from the Single-Story House Product Platform. The demand brought by the commercial team was for two different products, Product 1 is a single-story house of approximately 50 m², and Product 2 with approximately 100 m², with the required minimum areas listed in Table 1.

Table 1: Minimum Areas for Products 1 and 2

	Product 1 (50 m²)	**Product 2 (100 m²)**
Integrated living and dining room	8.00 m²	16.00 m²
Kitchen	4.00 m²	7.00 m²
Laundry room	2.50 m² or easily adaptable to 2.50 m²	4.00 m²
Suite (bedroom + bathroom)	12.50 m²	15.00 m²
Bedroom 1	10.00 m²	10.00 m²
Bedroom 2	-	8.00 m²
Social Bathroom	2.50 m²	2.50 m²
Toilet	-	1.80 m²
Covered parking space	-	12.00 m²

For Product 1, the objective was a 15% cost reduction compared to the existing reference product. And for Product 2, the objective was a cost reduction between 10% and 15% compared to the existing reference product.

The development of the two products was carried out with integration between commercial, platform, and engineering teams, and each one took approximately 45 days for the final architectural project to be approved by all. Both products were created using solutions and standardizations previously developed from the Single-Story House Product Platform, such as bathroom modules, standard window frames, roof solution and grouping of wet cores in few hydraulic walls.

In Figure 6 it is possible to observe the base reference for Product 1 and in Figure 7 final architectural plant of Product 1.

Figure 6: 50 m² Reference Product

Figure 7: 50 m² New Product

In Figure 8 it is possible to observe the base reference for Product 2 and in Figure 9 final architectural plant of Product 2.

Figure 8: 100 m² Reference Product

Figure 9: 100 m² New Product

The application of solutions developed by Company A's RD&I team for the Single-Story House Product Platform together with the application of the new product development flow, brought about a 16.7% cost reduction in relation to the base project of 100m² house and 18.9% cost reduction in relation to the base project of the 50m² house in the estimation costs. Both results surpassed the initial target, showing the success of the strategy. When the products are executed, it will be possible to measure the savings from the predicted waste reduction, considering that the applied standard solutions are completely mastered by the operations teams, and according to the revised theory, this mastery brings waste reduction, therefore, less cost with materials (Rocha, et al., 2015 and Gibb, 2001).

DISCUSSION

It is a fact that the cost increase that has occurred in civil construction in recent years has had a negative impact on the sector. Reduction in the number of real estate launches and companies going bankrupt was the reality faced since 2019 in the Brazilian market.

As seen in the literature analysis carried out, the use of the product platform has the potential to bring more control, predictability, and sustainability to the sector. The difficulty encountered is the same as reported by Rocha et al. (2015), there are still many differences between construction and manufacturing, and although there is a growing interest in industrialization and off-site construction, they still represent a small portion of the market.

The results with the application of the integrated product development flow proposed in this study meet the results expected in the study made by Ortega et al. (2022), where every stakeholder participates in the process, bringing ideas that can optimize and make the project more efficient. Moreover, the evaluations are more decisive and with a holistic view, and that reduces the rework that exists when different stakeholders participate in different stages of the development process.

As exposed by the UK Research and Innovation & Construction Innovation Hub (2022), the major gains from using product platform strategies are primarily related to the supply chain, where the advantage lies in the standardization of raw materials, which allows for better cost control through inventory and a diversified supplier portfolio. Company A's supply chain has already benefited from the product platform strategy and has reduced the quantity of different items in their bills of materials and managed to improve negotiations by concentrating a larger volume of standard material with its suppliers. The cost reduction can revert to a more competitive price, which leads to increased sales and reaches to lower-income groups where there is a large housing deficit.

This implementation could be done with small steps - for example, a construction company/developer could always work with the same sets of frames in different projects, this allows stock and makes them less susceptible to the increase in the cost of wood and steel - and gradually increase the standardization where to find possibilities. Secondly, the advantage related to the reduction of risks, which can be the risk of accidents at work – the more an employee repeats a function, the more he masters what he does – the risk of delays, whether due to lengthy lead-times, correction of projects, labour delay, among others, and risks of rework, since in the repetition, the activity is already validated and with reduced chances of error. This is also related to the third advantage, which is the environmental one. The less rework, less waste generation, and less carbon added to activities - UK Research and Innovation & Construction Innovation Hub (2022) even calculated a process with a 70% carbon reduction using a product platform.

All these advantages were part of the gains brought with the use of the new product development flow along with the standardization solutions already existing in the company. And as the study results show, there is a significant financial gain in standardizing, integrating decision-making processes and reducing waste.

Also, with the usage of the proposed flow, it is now possible for Company A to accept some level of customization by customers, without prejudice to production and process. With the client's participation and customization, their need to renovate their homes after the construction will be reduced, as proposed by Rocha et al. (2015), which also reduces the waste generated.

In this way, we can also observe that the use of a product platform can meet the economic, social, and environmental trinity.

CONCLUSIONS

As noted, the platform strategy is best applied in manufacturing, and off-site still has a small share in the construction industry. In this way, this transition will have a potential impact on the sector, when it reaches a large portion of the market. The potential impact may be a global reduction in costs since the results of this research show a significant cost reduction in a real case.

The cost reduction obtained was possible due to the integrated product development flow, that enabled important decisions to be made in the right timing, avoiding rework. Also, it allowed designers and decision makers to calmly and concentratedly evaluate which existing solutions would bring the best gain for each product, without external interference at inopportune moments.

The process and results in this study - where it was possible to put into practice the theories to validate them in the market - are important for Company A, as they are addressing recurring problems with new solutions that can reduce aspects that are currently negative, such as the amount of waste generated and the lack of control over raw materials and labour, or the lack of customization possibilities when standards are created. The opportunity to apply all the research in a real company was essential to measure the real gains from the application of product platform strategies and to report compliance with the initial cost reduction target expected by the company. Even though it was a limitation that one of the authors works in Company A, this research was only possible because of that and supports more integration between theoretical investigations and practical applications. Another limitation found is that the company started recently to apply and focus in product platform strategies. In a company that has their product platform consolidated, other gains not even approached in this study may be possible – such as standardization of processes in the production line. And the last limitation found in this case-study, is that the gains from waste reduction are not measurable in the project phase, only in the execution, therefore, this specific gain remains theoretical.

For the most part, the literature found is related to sectors other than civil construction, which indicates a large space for research and development.

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